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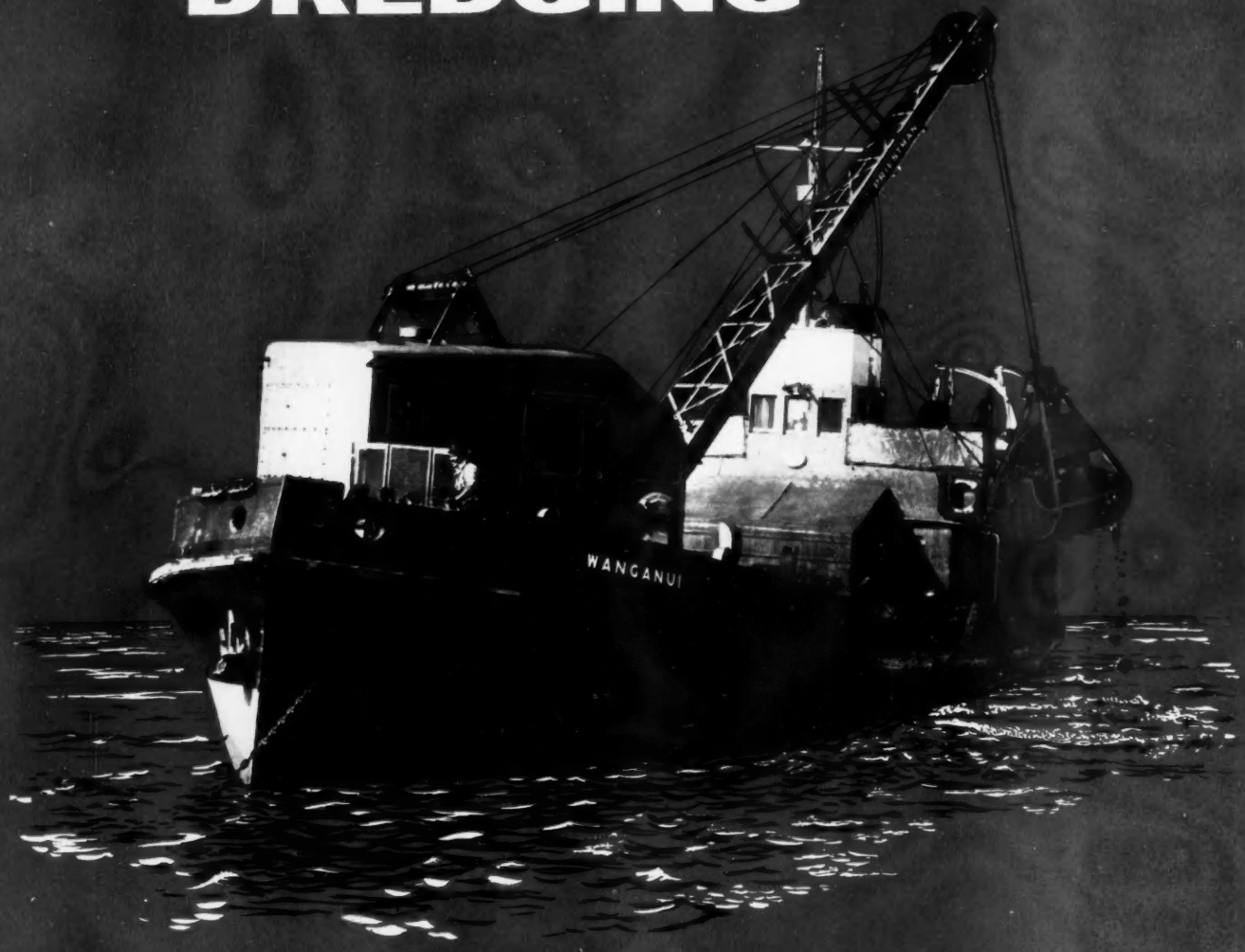

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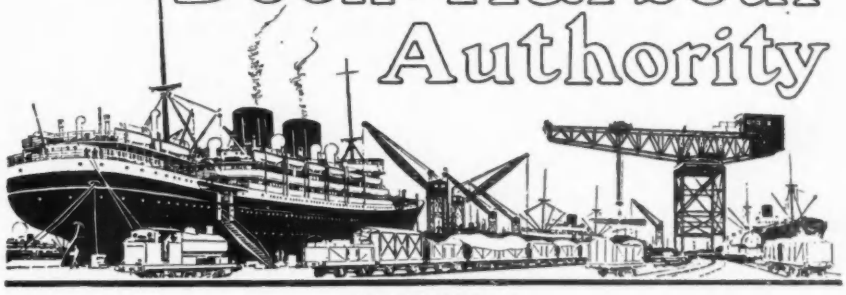

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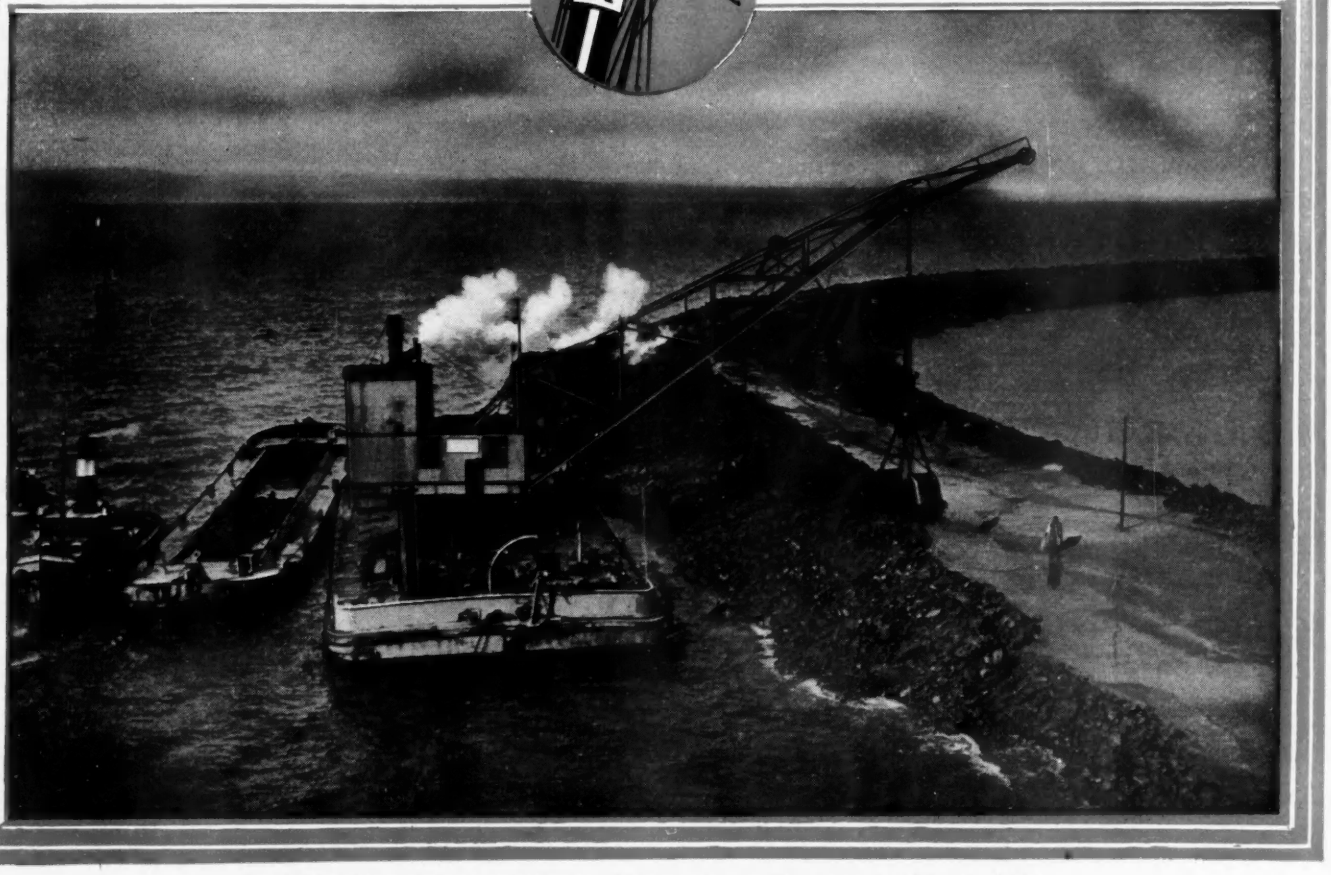

Leith Western Extension Works—Breakwater under construction in 1940

Leith was the first port in the United Kingdom to use this method of building breakwaters and experience has fully justified the claims that were made for this type of construction including the saving in initial cost and freedom from maintenance. The work was put in hand in 1936 and completed (not without difficulty) during the war, in 1942.

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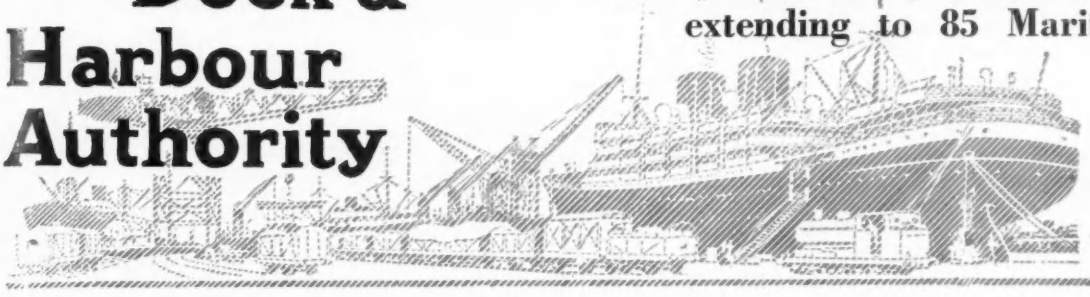


Editorial Notes

Duke of Edinburgh Dry Dock, Swansea.

The official opening last June of the Duke of Edinburgh Dry Dock marked another stage in the development programme of the Prince of Wales Dry Dock Co., Swansea. This phase of the programme has involved not only the construction of a modern and highly efficient dry dock, capable of accommodating ships of up to 32,000-tons deadweight, but also the extensive development of the company's dockyard and workshop facilities. The new dock, which was built at a cost of £750,000, is the largest privately-owned dry dock in the Bristol Channel and has taken two years to complete. It is part of the general improvement scheme, costing £1½ million, which the Company has been carrying out since the end of the Second World War.

The new dock has been built alongside one of the Company's existing docks—Palmer's Dry Dock—and is so designed that both docks can utilise the same pumphouse, cranes and other facilities. It is capable of taking the largest ships able to enter Swansea docks and has been planned to provide speedy and efficient handling of ships under repair together with a well-equipped outdoor workshop. All essential services have been provided to allow crews to remain on board their ships while they are in dock and underground oil tanks have also been installed to receive ship's oil during the inspection or repair of tanks.

As will be seen from the article on a following page, the construction works were carried out so as to avoid interfering with normal production and included the installation in the existing pump-room of a new 36-in. main dock pump with a capacity of 30,000-gallons per minute. The new dock also incorporates several features which have been planned after an extensive study of other dry docks in different parts of the world. The innovations include a system for controlled ship docking, a completely new development in this country, which allows ships to be winched into the dock under precise supervision. Another unusual feature is the system of bilge blocks which has been designed to eliminate the need for side shoring and thus give free access all round the ship. The usual shoring from the altar steps and dock walls has been replaced by adjustable bilge blocks which are located on the dock floor and engage the ship's hull at uniform pressure prior to dewatering the dock.

It is of interest to note that, at the opening ceremony, the Civil Lord of the Admiralty drew attention to the important part played by the ship repairing industry in the country's economy. He observed that it was not generally realised that ship repairers returned to service each week a tonnage of repaired ships equal to the total annual output of new ships.

This impressive output of repaired tonnage gives some indication of the extent of the industry, and in building this new dock at Swansea, The Prince of Wales Dry Dock Company has made a significant contribution by providing further facilities to meet the requirements of modern shipping. At the same time, the increased activity will undoubtedly be of direct benefit to the ports of South Wales.

Changes in Administration of Aberdeen Harbour.

A draft order for the setting up of a Harbour Board to administer the affairs of Aberdeen harbour and port was approved early this month by the Aberdeen Town Council. The effect of the order, which will come into force in January 1961, will be to transfer the affairs of the harbour from the commissioners, who hitherto have been largely dominated by the Town Council, to a permanent autonomous board on which the Town Council will have a minority representation.

At present there are 31 commissioners, appointed under the Harbour Act of 1895. They consist of the Lord Provost, 18 councillors and 12 others elected to represent shipping and other harbour and port interests. The new Board will be reduced to 15 and comprise only 4 members of the Corporation and 7 members elected to represent shipping and special interests. In addition there will be 2 members appointed by the Aberdeen Chamber of Commerce and 2 by the Scottish Trades Union Congress. Also, as a result of this change in responsibility away from the Town Council, the Town Clerk will cease to act as clerk for harbour affairs and a new appointment will be made for the position of Secretary to the Harbour Board.

Although autonomous the new Board will come under the supervision of the Minister of Transport; accounts will be subject to audit, charges will have to be in keeping with those laid down by the Ministry, and an annual return on borrowing and repayment of loans will have to be made to the Minister. Also, an upper limit to borrowing powers by the Board will be written into the order.

Hitherto it has not always been clear whether the Corporation or the harbour commissioners were responsible for some matters affecting the harbour and the draft order attempts to clarify the position. When it has been officially lodged next month, the order will make clear the limits of the Corporation's responsibility within the confines of the harbour for drainage, cleansing and policing. If there is any difference of opinion the order provides for the appointment of an arbiter by mutual agreement.

The creation of a permanent Harbour Board for Aberdeen has been long delayed. The Harbour Commissioners were established in 1895, originally for a period of 25 years, and the arrangement

was renewed from time to time until 1948. Since then, many proposals have been put forward including a suggestion that the harbour should be transferred to the British Transport Commission when the railways were nationalised. Fortunately, this plan was subsequently abandoned and the present plan for an autonomous Harbour Board seems by far the most satisfactory solution.

Dock Workers' Conference in Rotterdam

A conference of the dockers' section of the International Transport Workers' Federation (ITF) was held in Rotterdam from 26-30th September last, and was attended by thirty delegates from nine countries, Belgium, Denmark, Finland, Germany, Great Britain, Holland, Malta, Norway and Sweden.

After a review of progress to date in implementing the international dockers' programme adopted at the congress in Vienna in 1956, it was decided to set up a sub-committee to keep a watch on further progress. It was also agreed that this sub-committee should consider a report on the relative merits of time work and piece work to be prepared by the secretariat for a subsequent section conference.

A discussion on changes in methods of work in the ports brought about by the introduction of mechanisation, as well as on the social impact made by these new techniques, led to the adoption of the following resolution:—

"This conference, having had an exchange of information on experiences gained with mechanisation and similar measures in the port industries of different countries: (1) Endorses the position already commonly accepted in dockers' circles that measures of this kind are calculated to increase the overall efficiency of the industry; (2) Re-affirms that organised dock labour is desirous of taking a full part in ensuring the efficacy of all measures introduced after proper consultation between management and labour and after adequate and considered planning; (3) Draws attention to the importance of ensuring: (a) that there is a fair sharing of the fruits of increased productivity; (b) that increased productivity results also in an improvement in living standards and greater leisure for the worker concerned; (c) that there is no dislocation of the labour force and consequent social hardship; (d) that the standards of safe working are not undermined by the stepping up of cargo-handling processes ; (e) that provision is made for training and retraining in the skills required to meet technological development; (f) that provision is made for severance pay and resettlement of labour displaced as a result of mechanisation and similar measures."

The conference also discussed vocational training for dockers. Stress was laid on the need for more systematic instruction in the skills needed to meet the demands made by modern methods and equipment employed in cargo handling, as well as on the importance of adequate training in the prevention of accidents. The conference also felt that the training of young workers should not be allowed to have an adverse effect on the wage structure and evaluation of key grades such as talleymen, cranemen, &c.

The question of dockers' old-age pensions was discussed in relation to the relevant paragraph of the international dockers' programme of the I.T.F., which states that a man on attaining the age of 65 and completing 30 years' employment in the port industry should receive a total pension equal to at least 75 per cent of his wage, with the option of retiring on a proportionate pension between the ages of 60 and 65.

Whilst reports made by different unions showed that substantial gains had been made in this respect in a number of countries, the problem everywhere was that of financing the pensions of those dockers who were already advanced in years at the time the pensions schemes were initiated. After some discussion the conference decided that the time had not yet come to lower the pensionable age from 65.

50 Years of Ship-to-Shore Radio.

This year marks the jubilee of the marine radiocommunication service of the General Post Office, which began in 1909 when the Lizard Radio Station was purchased from the Marconi International Marine Communication Company, Ltd., together with five other stations at Niton, Caister, Seaforth (Liverpool), Rosslare and Crookhaven. From Lloyds were acquired two further stations, Malin Head and North Foreland. These eight stations, with an operating staff of 40, provided a short range distress and radio telegraph service for the 286 British ships then equipped with radio as well as for a few radio-equipped foreign ships.

In 1910, this small staff dealt with nearly 50,000 messages. Today, fifty years later, the Post Office staff of 225 handle 850,000 messages each year and act as shore link for 6,300 British and 3,000 foreign ships. Although some of the stations have been resited, most of the original ones are still working. Later this year the one at Seaforth will be replaced by a new station at Anglesea. This station and the two new stations built during the past two years at Stonehouse and Ilfracombe are probably the most up-to-date in the world.

Provided international telephone links exist, it is possible for a ship at sea to communicate with any country in the world. One of the important uses of the Coast Radio services, which is given free to ships of all nations, is the distress service which comes to the aid of ships in peril or when injury or illness make expert help essential. During such a distress call normal working is suspended so that quick assistance can be given.

At a reception held early this month to mark the golden jubilee, the Postmaster-General sent messages to the radio officers of all British ships and to staffs of coast radio stations. He also recalled that Marconi and Lloyd's were the pioneers of ships radio telegraphy and said they deserved an extremely high tribute for the way in which they had developed the service in their day.

United Kingdom Pilotage Services

The annual conference of the United Kingdom Pilots' Association was held in London from 10th-11th November on board H.Q.S. "Wellington". The meeting, which was better attended than in previous years was under the chairmanship of Mr. D. H. Tate (Tees), the senior vice-president.

In reviewing the year, Mr. Griffiths the general secretary, said the Association accepted without reservation that it was a basic condition of the Letch committee's recommendations on earnings that the number of pilots licensed was in fact the proper number for the district and that rates should be fixed and where necessary adjusted to produce for that number the net earnings recommended. That undoubtedly was the right principle but unfortunately as a result of redundancy it was proving most difficult to apply in practice.

Regarding the continuation of the apprenticeship scheme as a method of enlistment to the pilotage service, Mr. Griffiths pointed out that not only were the majority of existing pilots in early middle age, but there was also a large waiting list of long-since qualified apprentices, and nearly double the number of apprentices serving, as there were pilots at the moment. Despite this, new apprentices were being regularly taken on. The authorities must know that there was little real prospect of many of these young men ever obtaining their licenses.

In the ensuing discussion the problem of redundancy among pilots in the smaller ports due to declining trade was referred to at length and a resolution was carried calling for the absorption of redundant pilots into the pilot service of other ports of a similar status. A suggestion was also put forward that pilotage could be more efficiently carried out if all the ports were united under one authority—the United Kingdom Pilotage Authority, which could control, administer and standardise pilotage. Present pilotage rates and the question of pensions were also reviewed.

The Duke of Edinburgh Dry Dock, Swansea

New Features to Facilitate Ship Handling

By J. READ, M.A., A.M.I.C.E.

WHEN it was decided in 1922 to build a ship repair yard at Swansea sufficient land was acquired and the premises laid out to form a compact unit around two dry docks. In 1923, however, only the first of these docks was constructed and it was not until 1957 that the owners, the Prince of Wales Dry Dock Co. of Swansea, were able to undertake the construction of the second larger dry dock.

In determining the size of the new dock the owners had to bear in mind the considerable increase in number of large tankers now afloat and they decided that it would be prudent to cater for the largest ships able to enter the Port of Swansea. The dimensions finally chosen are: length 670-ft., width at entrance 92-ft. with an average depth of water over the sill of 21-ft. The depth of water provided may appear to be small when compared with normal practice in earlier years but it should be remembered that the depth is a major factor governing the cost of the dock and that it was anticipated the larger ships docked would be bulk carriers of one kind or another and such ships are of smaller draught than dry cargo ships of similar length and beam. In fact the dock can accept tankers of up to 36,000 tons deadweight.

The owners also decided to incorporate several features at present unusual in this country but becoming widely spread on the continent of Europe. These were the special arrangements for handling the ship while docking, the provision of bilge blocks that can be adjusted to the hull after the ship has settled on the keel blocks but before emptying the dock, the provision of travelling scaffolding to facilitate the speedy completion of painting and the fitting of waterproof fluorescent lighting under the top altar to illuminate the space between dock wall and ship's side. In addition, ships in the dock can use their own internal sewage disposal systems by making temporary connections to two 6-in. sewers that have been incorporated in the dock floor.

The Dock Body

The contractors responsible for the construction of the first dry dock had kept careful records of the types of ground found

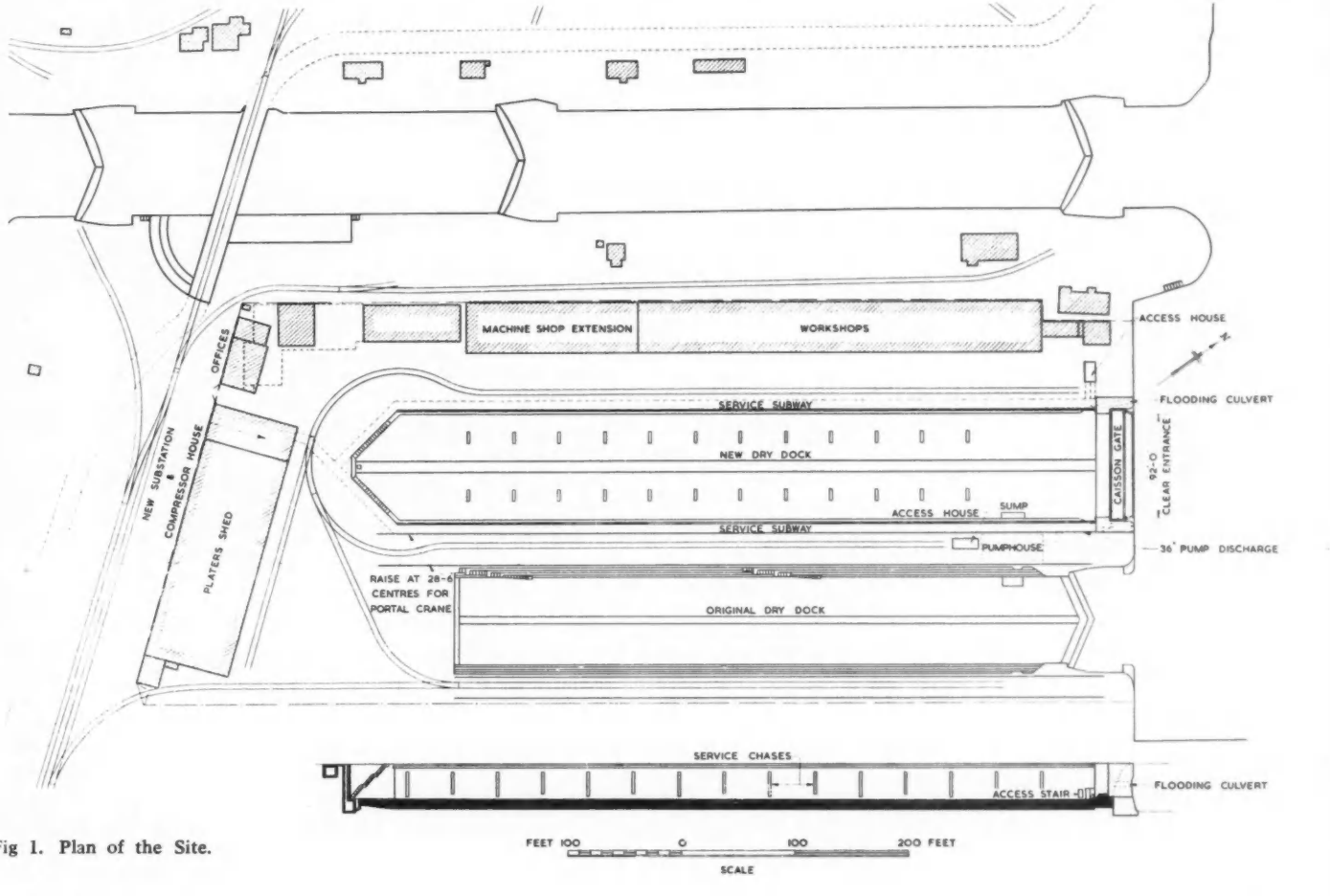


Fig 1. Plan of the Site.

and this information together with that from further boreholes and pumping tests upon the site of the new dock enabled a very clear picture to be drawn not only of the conditions to be considered in design but also those likely to be encountered during construction.

The area of the site originally lay between high and low water of spring tides and was reclaimed at the time of the King's Dock construction. The former beach deposits lie about 20-ft. below the present ground surface, the overlying material being mainly ballast derived from the excavations for the King's Dock and the existing dry dock. Below the beach deposits layers of soft clay were encountered. Over the whole site standing water level was about 13-ft. below the surface, some tidal fluctuations being noticeable.

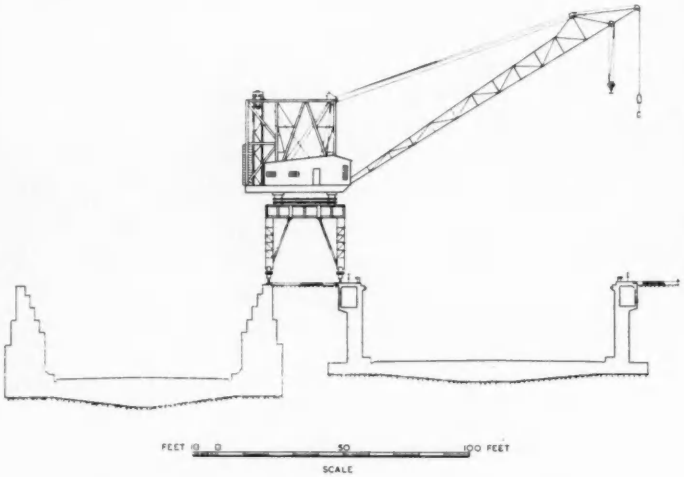


Fig. 2. Cross-sections of the old dock (left) and the new dock (right).

In these circumstances it was decided that the most economical form of construction would be in reinforced concrete, the substantial floor spanning as a beam between the side walls and projecting behind the side walls to prevent flotation by mobilising as ballast the weight of the backfill behind the walls.

With the provision of the adjustable bilge blocks no altars are required for shoring ships and the wall face is therefore vertical from the top of the bilge altar to the cope apart from the small nib just below cope level. This nib carries the rails upon which the hauling carriages run when docking a ship. The bilge altar itself is higher than usual in order to accommodate recesses for future submersible lighting fittings which are to be at 20-ft. centres along the parallel portion of the dock. These recesses alternate with steps to render access to the bilge altar easy.

At the head of each side wall, and continuing around the head of the dock is a service subway of generous size housing piped and electrical services together with the operating mechanisms for the adjustable bilge blocks. Because of the equipment installed in this subway and because of its direct connection with the pumphouse it was important to ensure that the subway would not be flooded in the event of a high water level in the dock. It was found that the highest recorded level in the docks was little more than 2-ft. below cope level making the provision of open ports for service connections in the wall of the subway facing the dock impracticable. All services therefore terminate in small pits let into the roof of the subway in which connections can be made for the various temporary supplies to docked ships. This has the advantage that all such connections can be made at cope level.

The scheme of running carriages along the cope edge on each side of the dock to which a ship can be made fast the more easily to control its motion demands that the cope edge be clear of such obstructions as access ladders so that while it is possible to provide external stairs at the extreme head of the dock some alternative form of access is required at the entrance. At points immediately within the entrance on the West of the dock and adjacent to the pumphouse on the East of the dock the side walls are thickened locally and the stairways formed within the thickness of the wall.

Construction commenced at the entrance immediately behind the wall of King's Dock and proceeded generally towards the head of the dock. Over the area to be occupied by the dock the ground level was reduced to 17-ft. below the general level, the spoil being removed by dragline in open excavation. From this level trenches were excavated between steel sheet piling and the side walls built within these trenches up to a level just beneath the service subway until after sufficient length of wall has been completed excavation of the dumpling between the walls commenced and upon formation level being reached the floor bays were concreted in four sections. Each bay was about 20-ft. long and the majority of the concrete was poured in three blocks with joggled construction joints, the fourth pour being a layer 12-in. thick on top of the previous pours and containing the high tensile steel reinforcement. To maintain the stability of the walls against the earth pressure the walls extended sufficiently far ahead of the floor construction for their ends to be supported by the unexcavated dumpling and only sufficient excavation of

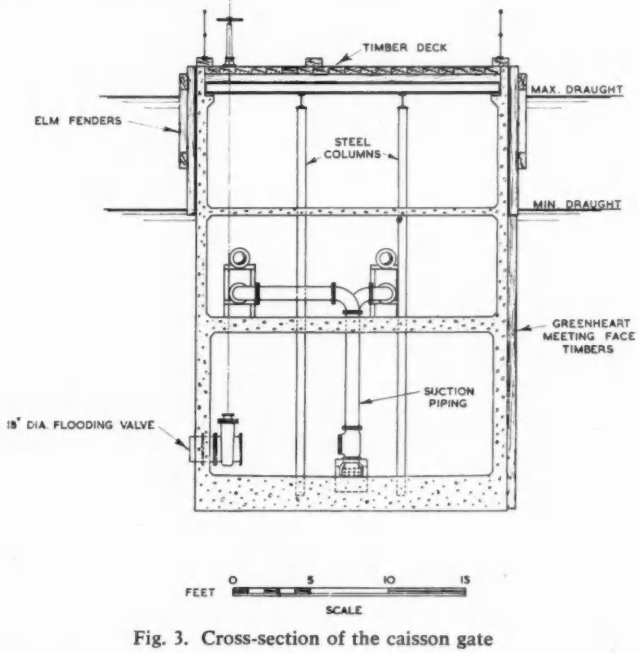


Fig. 3. Cross-section of the caisson gate

dumpling was permitted to allow the construction of one floor bay at a time.

As has been predicted considerable pumping was required and in the seventeen months during which the wall stems and floor was being constructed it is estimated that approximately 1,000 million gallons were pumped from the workings.

Dock Entrance

The new dry dock opens directly into the Kings Dock and its construction involved the demolition of a section of the existing quay wall, the reinforced concrete of the dock body being grafted to the old quay wall by mass concrete side walls and sill. In-

corporated within each entrance block is a 48-in. diameter flooding culvert while in the Eastern wall is provided a 36-in. diameter pipe for the discharge to the wet dock from a new pump installed in the existing pumphouse.

The construction at the entrance commenced with the work behind the old wall, the breaching of this wall being left as late as possible as it was felt that the solid masonry provided greater safety against damage by collision than would the temporary single skin sheet pile cofferdam formed across the entrance to the wet dock. The cofferdam was first strutted from the old quay wall but as demolition of this wall proceeded the struts were transferred to the newly completed sill and side walls.

Following the earlier successful use of precast granolithic concrete meeting faces similar units were employed in this dock. Each unit was cast upon a rigid bed faced with a steel plate machined to a fine tolerance and after curing was concreted into its final position. Joints between adjacent units were filled with similar concrete poured against a machined steel shutter and such was the accuracy achieved in setting these units to line and level that only light surface grinding was required to complete the meeting face.

Concurrently with the main dock construction a reinforced concrete caisson gate was constructed upon a convenient area of completed dock floor. This gate was of cellular construction 97-ft. long, 20-ft. wide and 28-ft. 6-in. deep, divided into three main compartments by two transverse diaphragms and having two intermediate decks, being completely of concrete apart from a timber top deck supported by steel columns and joists. Fig 3 shows the cross-section of this gate. Greenheart timbers fixed to the concrete of the gate and carefully dressed after erection transmit the thrust from the gate to the concrete meeting face

Fig. 4. View from head of dock

but reliance has not been placed upon the accuracy of finish to ensure watertightness. A rubber seal in the form of a channel section is secured by steel flats and coach screws in a groove cut in the centre of the timbers, pressure on the edges of the flanges protruding beyond the timber producing an effective seal.

In operation the central compartment is allowed to flood through an 18-in. diameter sluice causing the gate to sink upon concrete bearers just outside and below the level of the meeting face, the valve being left open whenever the gate is in position to avoid any possibility of the gate lifting due to variations of water level in the King's Dock. To remove the gate once the dry dock is flooded two 8-in. diameter diesel-driven centrifugal pumps remove sufficient ballast water for the gate to rise about 1-ft. above its bearers when it is manœuvred from the entrance and laid across the entrance of the existing dock.

The choice of gate was made after a consideration of the "Box" flap gate, the single skin flap gate and the concrete caisson had shown that the "Box" gate would cost approximately twice as much as the caisson while the single skin flap gate

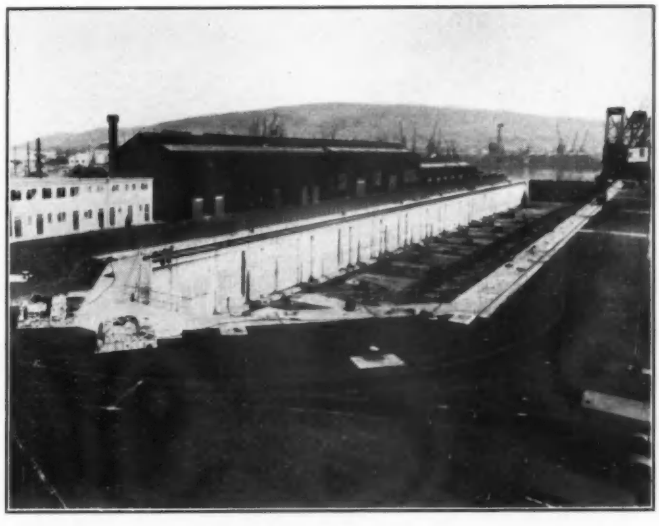


Fig. 5. General view of yard

which was intermediate in cost was impracticable due to the continuous dredging it would require to maintain sufficient depth of water in the King's Dock for its operation.

Pumphouse

The pumphouse built at the time of the construction of the first dry dock was so arranged that it could serve the second dock, flexibility of operation being provided by controlling the entrance of water from each dock into the pumphouse sump by four 54-in. dia. sluice valves. It was considered advisable, however, to augment the original pumping capacity. Available space precluded the use of a further horizontal spindle centrifugal pump similar to those originally installed and instead a 36-in. dia. axial flow pump was supplied and erected by Sulzer Bros. (London) Ltd. who also supplied and erected a 10-in. dia. vertical spindle pump arranged to act either as a further drainage pump or to supply ballast water for the ships in dock. The discharge from the main pump reaches the wet dock by way of a siphon the crest of which is above the highest known level of water in the wet dock. Back siphonage is prevented as soon as pumping ceases by the automatic opening of a paddle operated air valve.

With a medium sized ship in dock two pumps out of the three can complete the dewatering in approximately 2½-hours although this time is usually exceeded as pumping is stopped for the necessary adjustment of moorings and bilge blocks.

Equipment and Services

With the knowledge that the system had been successfully used on the Continent, notably at the new dry dock of Burmeister and Wain in Copenhagen, it was decided to provide the means for hauling a ship into the dock without use of the ship's machinery and under the complete control of a docking master (See Fig. 6). On each wall just below cope level a nib is provided in the outer corners of which are set continuous 6-in. x 6-in. x ½-in. angles tied into the concrete with mild steel

flats at 18-in. centres. Welded to the top of the upper angle a 2½-in. square steel bar forms the rail upon the top and rear of which the upper wheels of the hauling carriage bear to withstand the pull from the towing rope. The lower angle acts as a smooth running surface for the lower stabilizing wheels of the carriage. A hook, capable of being tripped from the cope, is attached to the upper part of the carriage and is designed for a working load of 30-tons.

Each carriage is hauled along the length of the dock by a 10-ton Pitt-Scott winch arranged for manual control when hauling in and automatic load control when undocking the ship. While the winch is rendering, the operator can control the load in the rope between the limits of 1-ton and 10-tons pull.

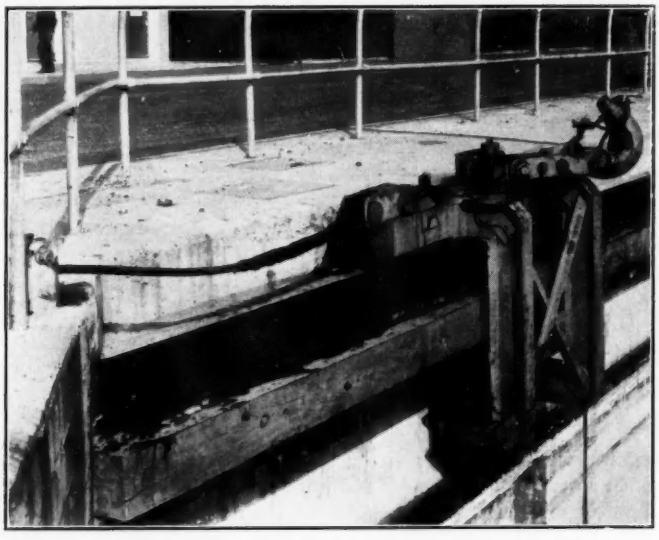


Fig. 6. A hauling carriage

The console controlling the winches is placed on the centreline of the dock approximately 13-ft. above cope level at the head of the dock thus providing an excellent view of the ship during docking or undocking. When entering the dry dock the ship is first centred in the entrance by the hydraulic capstans on either side of the dock and the towing ropes attached to the hauling carriages; then with the ship's stern restrained by a tug the winches haul the ship into the dock the operator adjusting the pull of each winch to maintain the ship's bow on the centreline of the dock. On leaving the dock a tug tows the ship out and controls the stern the winches being used as brakes the restraining force of which can be chosen by the operator to suit the weather conditions and size of ship.

A review of the various types of adjustable bilge block at present in use both in this country and abroad suggested that those developed by Messrs. Burmeister and Wain of Copenhagen were the most suitable having regard to both function and economy and permission was therefore obtained for this design to be adopted.

The form of these blocks can be seen from the accompanying illustration (Fig. 7) the base wedge being of steel with a timber block resting upon it, varying rises of ships floors being accommodated by the tilting head. When in use the block can be removed under load by releasing the wedges in the timber block that are normally held together by bolts.

In operation the wedge with the timber block placed at its thin end is left near the bilge altar until the ship has settled onto the keel blocks; the complete block is then hauled in towards the centre of the dock until an indicator in the service subway shows that the head of the block is the correct distance from the dock centreline at which moment the mechanism driving the timber block is declutched from the source of power and locked against rotation. Continuing movement of the wedge towards the dock centreline then raises the block head into contact with the ship's bottom.

The movement of each bilge block is controlled from within the subway, power from an air tool being transmitted to the chains connected to the block by a worm reduction gear driving two concentric shafts passing through the subway wall and carrying chain wheels at their outer ends The inner shaft is permanently connected to the reduction gear while the outer shaft can either be connected by a sliding clutch or disconnected when it is locked against rotation and holds the head of the block against further movement.

A total of 12 pairs of bilge blocks have been fitted and with a safe load of some 200-tons each will be adequate to support the largest ships able to use the dock.

During recent years it has become a common practice for the crews of ships to live on board while the ship is in dry dock. This raises the problem of providing adequate facilities for the men living aboard and here the opportunity was taken to include contruction two 6-in. dia. sewers in the dock floor to which connections can be made so that the ships own sewage disposal system can be used. The two sewers drain into a sump at the head of the dock where an ejector has been installed in a pit within the thickness of the dock wall. From there the sewage is lifted by the ejector and discharged into the yard sewers. Connection to the sewers in the floor is possible at 40-ft. centres each connecting point being sealed when not in use by a screw-on cap.

Dockside services for both docks are routed through the service subway of the new dock connections for the piped and some electrical services at the cope of the existing dock passing through subsidiary culverts to recesses in the old dock wall.

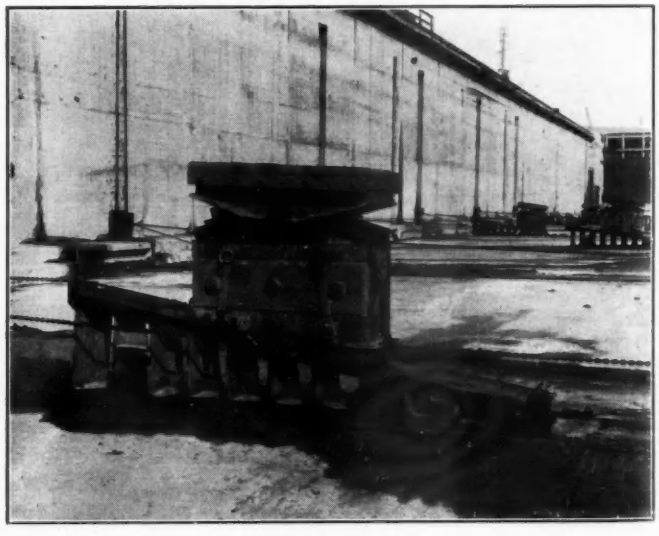
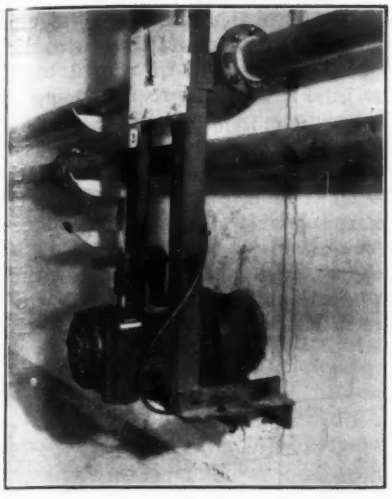


Fig. 7. A sliding bilge block

The services provided are as follows:— ballast water, process water, drinking water, compressed air and steam together with a pipe to transfer oil from a ship's tanks to two storage tanks built below ground immediately behind the dock walls at the apex of the dock. In addition welder supply points are placed at 200-ft. centres along both sides of the dock with provision for duplicating this supply if necessary. Provision has also been made for a piped service of oxygen and acetylene if the demand warrants its installation.



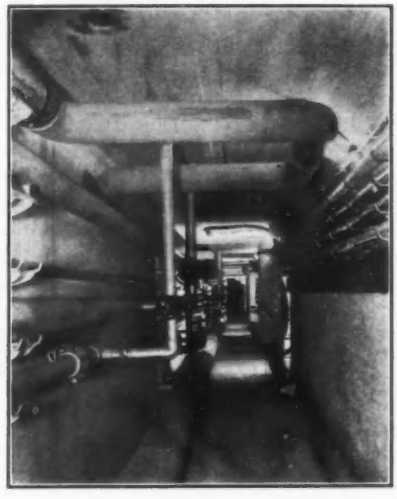


Fig. 8 (left). Operating mechanism for a sliding bilge block.
Fig. 9 (above). A submersible fluorescent lighting fitting.
Fig. 10 (right). Interior of Service Subway.

The compressed air, salt water and provision for oxygen and acetylene have been extended to the dock floor the oxy-acetylene pipes and electrical connections terminating by the keel blocks where they are protected from water when the dock is full by air bells, the compressed air and water pipes ending at the foot of the wall.

Having arranged that all the services at cope level terminated in the subway roof it was decided that the handrails should be placed five feet back from the cope edge thus keeping all normal traffic away from the service pits. It was felt that handrails at the cope edge would not provide a greater degree of protection against accidents as they would have to be removed for each docking giving no protection to anyone during this period whereas in their actual position they need be removed only on rare occasions. Adequate space is available behind the rails for all normal traffic and only those men requiring to handle ropes or to fix the temporary service connections need to be between the rails and the cope edge.

Throughout the parallel section of the dock handrail stanchions are set at 4-ft. and 6-ft. centres the shorter bays being fitted with telescopic rails to enable ships' gangways to be erected at any convenient spot.

Dockyard Lighting

General lighting of the yard at night is provided by four lighting towers, two being set on the roof of the platers shed and two on the staircase access houses at the entrance of the new dock, in conjunction with a line of lighting columns along the Eastern boundary. Within the new dock submersible fluorescent lights are fitted beneath the hauling carriage nibs to illuminate the space between the ships side and the dock walls (Fig. 4) while electric plug sockets on the dock centreline enable portable cluster lights to be set up beneath the ships bottom with the minimum of trailing cables. Provision has been left for the later installation of submersible fluorescent lights in the bilge altar to give a more general illumination beneath a ship.

Other Works

Whilst the new dock was being built the opportunity was taken to extend the yard's facilities. The existing standard gauge track was removed and a new layout provided to enable a Coles diesel-electric rail crane of 15-tons capacity to be used around both docks and in the area outside the platers shed. As the surface was to be finished with tarmacadam flush with the rails prestressed concrete sleepers were preferred to timber and all rails were guarded with bulb angles except on the inside of curves where rail was substituted. Some settlement of the tracks was anticipated particularly over backfilled areas and the surfacing was not completed until the rail tracks had been repacked following sufficient use to produce an appreciable settlement. At points where the tracks crossed structures unlikely to settle slabs were provided at the transition points in order to avoid sudden changes of line that might cause crippling of the rails and these measures appear to have been successful in avoiding any damage to the tracks due to settlement.

The extension of the existing steel framed workshop building enabled the machine shop to be extended and gave additional space for a new garage and stores, while the new electrical switchgear was housed in a substation, contained within the end of the existing platers shed. To this new building was transferred the existing switchgear and one room on the ground floor was used for three new air compressors each of 500 c.f.m. capacity. The first floor of the substation houses the electricians and the mess for the boilermakers.

General

The total time for the construction of the dry dock, the ancillary equipment and the buildings was approximately 30 months, the dock itself being commissioned in June of this year some four months before the final completion of the work.

The main contractors for the work were Messrs. Marples, Ridgway and Partners Ltd. of Lygon Place, Victoria, S.W.1.

The consulting engineers to the Prince of Wales Dry Dock Co. (Swansea) Ltd. are Messrs. G. Maunsell and Partners of 66, Haymarket, London, S.W.1.

Development of Port Louis, Mauritius

A grant of £540,000 towards the cost of improvements to Port Louis Harbour has been approved under the Colonial Development and Welfare Act. This scheme to improve the facilities of the harbour is an integral part of a £15¾ million 5-year development programme which was approved in 1957 by the Legislative Council. Two new lighthterage quays are to be constructed on the north side of the harbour, while an existing deep-water quay will be strengthened and extended to link with them. A central Customs area with adequate hard surface for open storage, transit sheds and access will be developed and a site will be reserved for the possible erection of sugar silos in the future. Present imports amount to an annual total of about 350,000-tons, including 50,000-tons of petroleum products and 50,000-tons of rice and pulses; main exports consist of some 530,000 long tons of sugar per year. The harbour development scheme was drawn up by the Mauritius Government on the advice of Messrs. Coode & Partners, Consulting Engineers, London.

Hydraulics Research at Wallingford

Abstracts from Report for 1958*

The work during 1958 of the Hydraulics Research Station, Wallingford, of the Department of Scientific and Industrial Research, has again covered a wide range of problems in the field of civil engineering. A majority of the investigations have been concerned with specific problems and have been carried out on a repayment basis, but background research into problems of more general application has also been in progress. The following abstracts of their Report, published on August 27th last, contain accounts of investigations that are of interest to readers of this Journal. In addition, there were a number of other investigations which have only recently started.

The Thames Estuary

The general study of the Thames Estuary was largely completed in 1957. Work on localised problems has however continued on the models of the estuary operated by the Port of London Authority under the direction of the Hydraulics Research Station, and further analyses have been made of data collected during the investigation. The following is a brief description of three of the problems studied.

1. Siltation in Gravesend Reach

In some recent years the amount of dredging carried out annually in lower Gravesend Reach (See Fig. 1) has exceeded the total quantity dredged annually from all the other tidal reaches of the river. The siltation has been so rapid that the authorised channel depth of 29.25-ft. below Low Water datum has only been maintained with difficulty. The constriction in the river at and immediately below Tilburyness produces high velocities and turbulence, with the result that large quantities of silt can be carried in suspension on both flood and ebb flows. To the east of this constriction, the waterway widens considerably—the cross-sectional area below mean tide level at mile 28.5 being nearly 42 per cent greater than at mile 26.2—and in consequence velocities are lower, turbulence is less and some of the suspended load is deposited. A second point is that the shipping channel through the reach has been buoyed and dredged on a straight alignment nearer the northern than the southern bank, whereas the natural alignment is on a curve, particularly at the wider, eastern end; silting is therefore to be expected on the north side at the eastern or seaward end which would be the inside of the natural curve. Surveys and bed sampling in the areas where dredging is carried out indicated that silting always occurs from the northern side of the channel. Also, as a result of the frequent dredging, the mud is largely unconsolidated and can easily slice or flow into a newly-dredged cut. In contrast, the bed to the south of the channel, where little dredging is required, appears to be relatively hard and consolidated.

It therefore seemed possible that it might be advantageous to realign the shipping channel on a curve to the south of the existing channel. Accordingly experiments were made on the 1/600; 1/120-scale model of the estuary to examine the effects of such a change in alignment.

Both the model experiments and the field investigation indicated that a southerly channel would be self-maintaining to a greater extent than the present channel and, consequently, that the amount of dredging would be substantially reduced. The newly-aligned channel should present no navigational problems as it would continue to be straight, though on a slightly more southerly bearing, throughout the greater part of Gravesend Reach, with a curve of somewhat larger radius at its seaward end. The Port of London Authority were therefore recommended to carry out the capital dredging necessary to re-align the channel in a more southerly position at the lower end of the reach.

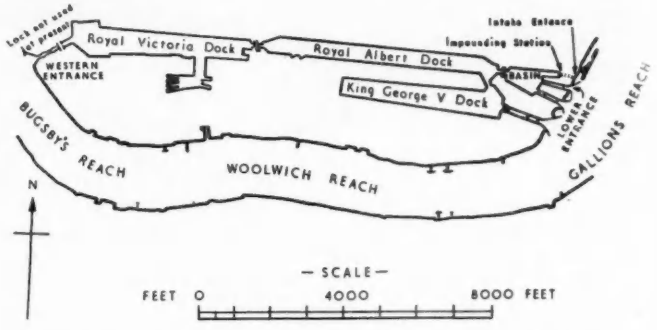


Fig. 2. The Thames Estuary. Key Plan of the Royal Docks.

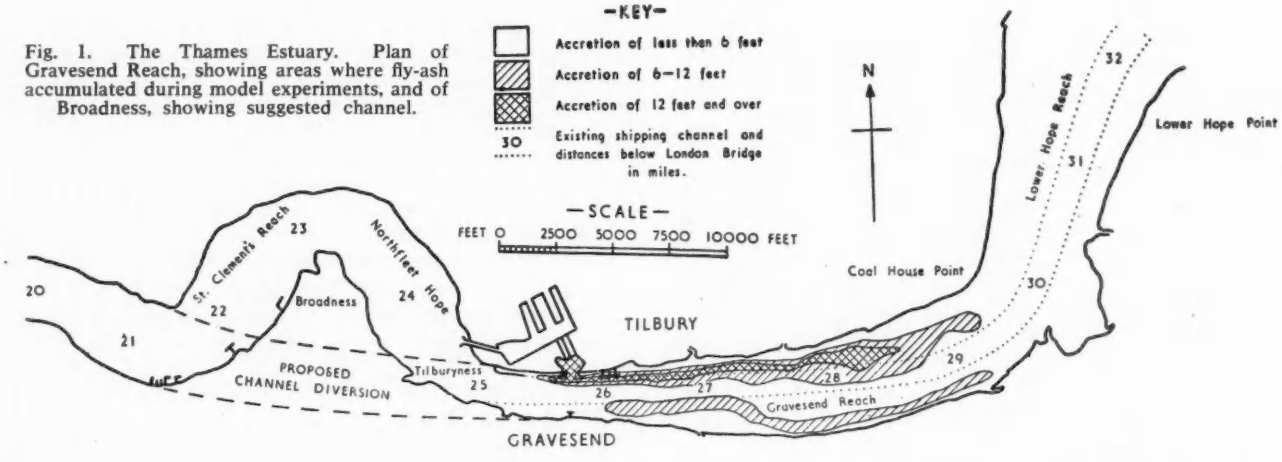


Fig. 1. The Thames Estuary. Plan of Gravesend Reach, showing areas where fly-ash accumulated during model experiments, and of Broadness, showing suggested channel.

2. Reduction of Siltation in the Royal Albert Dock Basin

Considerable dredging is necessary in the Royal Albert Dock Basin (Fig. 2) to remove the large quantities of silt brought into the Basin with the river water impounded to maintain adequate depths for shipping in the Royal Docks system. A preliminary study of the conditions suggested that by making suitable changes in pumping practice it might be possible to reduce the amount of silt carried in; and an investigation of the pumping practices was therefore put in hand.

Experimental work on a 1/40-scale part-width model of Gal-

*"Hydraulics Research 1958," annual report of the Hydraulics Research Station, Wallingford, Berks, is published for D.S.I.R. by H.M. Stationery Office, price 5s. 6d. (99 cents U.S.A.) by post 6s. 0d.

lions Reach and the intake showed that the pumps drew silt-laden water from near the bed of the river as well as the clearer surface water. It was also shown that it would be possible to construct an intake flume extending riverward of the bank and jetties so that surface water only was drawn into the pumps. Data obtained by sampling indicated that if this were done the amount of silt impounded could be reduced by up to 40 per cent. Unfortunately, the essential extension of the flume beyond the jetty line was considered to be unacceptable from the point of view of navigation. In practice therefore it appeared that the maximum reduction that could be achieved by modifications to the intake would be about 10 per cent.

3. Broadness Cut-off

It is possible to bring about an overall improvement in depths in an estuary by reducing energy losses at bends and constrictions, so increasing the tidal discharges. Energy losses in the Thames Estuary would be reduced if the three sharp bends in the river at Broadness were to be eliminated by cutting a new channel to join Long Reach directly to Gravesend Reach (See Fig. 1). It was decided to examine the possible effects of such a channel on conditions in the estuary, and the 1/600-scale model was accordingly modified in the vicinity of Broadness so that both the existing channel and the cut-off channel could be reproduced.

The model was operated with a mean tide similar to that which was recorded on 26th June, 1953; the natural salinity distribution was reproduced and a low upland flow of 1,100 cusecs was fed into the model at the upstream end. Tidal levels, current velocities and salinities were measured at a number of points, first with the natural river channel, then with the new cut-off channel and finally, as a check, with the natural channel again.

It was found that the cut-off caused the tidal range upstream of Broadness to be increased by 0.3 to 0.4 ft. and the salt penetration to be extended upstream by about one mile. The effects on the longitudinal salinity gradient and the rate of progress of the tidal wave up the estuary appeared to be very small. As the progress of the tidal wave was virtually unaffected, the increase in tidal discharge upstream of Broadness would be of the same order as the increase in range, i.e. about 2 per cent. In the circumstances it is difficult to assess what average increase in mean depths such an increase in discharge would bring about, but a consideration of regime formulae for rivers and canals suggests that the improvement in the Mud Reaches might be about 4-in.

More detailed studies of the effects of the cut-off channel on tidal discharges could have been made, but the additional work did not appear to be justified in view of the small improvements indicated by the first tests and the considerable difficulties that would be encountered in constructing the cut-off.

The Mersey Estuary

Briefly the aims of the investigation of the estuary of the River Mersey are to predict future trends in the estuary from the point of view of siltation and, if possible, to suggest means of increasing depths over the Garston and Bromborough Bars (Fig. 3). The advisability of continuing with the extensions to the training bank on the south side of Queen's Channel is also to be investigated. A general study of the estuary is therefore being made, and two models and a special survey team are being employed; one model is of the Upper Estuary and has scales of 1/550 horizontally and 1/60 vertically; the other is a 1/3,200; 1/120-scale model of the whole of Liverpool Bay and the Mersey Dee estuaries. Extensive records of the estuary and the bay covering the last 120 years have been made available to the Station and are providing much valuable information. Analysis of these records has shown that a major part of the large quantity of material dredged each year from the Upper Estuary must enter from the sea.

Measurements made in the Narrows showed a difference in salinity between bed and surface water of 1 or 2 parts per thousand. Although this difference was small, previous work on the Thames model had indicated that it could be an important factor in the development of a landward drift near the bed. As such drifts are important in relation to the general movements of water and solids into and out of the estuary, detailed measurements of current velocities and suspended solids have been made in the prototype during the past year. The observations were taken on a section across the river from the Cammell Laird Slipways to Brunswick Dock Entrance, the section being divided into four equal parts and observations made on the centre-line of each part.

At the second position, counting from the Cheshire bank, a pronounced landward drift was found at the bed; furthermore, when the tidal range exceeded 21 ft—the range of tide at Princes

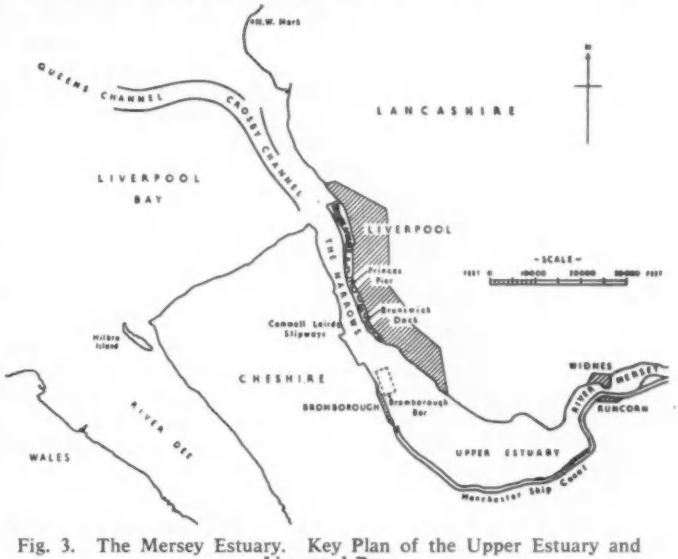


Fig. 3. The Mersey Estuary. Key Plan of the Upper Estuary and Liverpool Bay.

Pier varies from 11-32 ft.—it was found that substantial quantities of material in the silt range were being transported landward. At the third position, the drift was similar but a considerable proportion of the material transported consisted of sand in suspension in the water immediately above the bed. Another point of interest was a marked movement of water at the bed across the estuary from the Lancashire side towards Cheshire.

Measurements similar to those taken in the field were made on the model of the Upper Estuary. Before this done, the proving of the model for reproduction of tidal levels had been completed and observations of the velocity distributions had confirmed that there were no effects similar to the natural density effect when the model was operated with fresh water throughout. Salt water was then supplied to the model at the downstream end so that the natural longtitudnal and vertical salinity distributions were satisfactorily reproduced. Subsequent measurements made at points corresponding to positions 2 and 3 showed landward drifts near the bed of the model closely similar to those observed landward drifts near the bed of the model closely similar to those observed in the prototype. A model survey of the circulation pattern in other parts of the estuary was then made, and it is now proposed to conduct experiments with a mobile bed.

Further analyses have been made of the records of Liverpool Bay in order to obtain a more complete picture of the changes that have taken place there. The assessment of the changes was not straightforward because of the large-scale dredging and dumping in the area, but it now seems clear that there is a

net movement of sediment into the Liverpool Bay area. It is therefore important to discover the source of the material and to determine the pattern of movement in the Bay itself. There are two possible sources of the material: from offshore and from littoral drift along the North Wales Coast. As the latter was considered to be the more probable source, a study is being made of the coast of North Wales to examine changes taking place there. In addition, radio-active tracers are being used to determine the directions of movement of sand in the Bay, and fluorescent material may later be used on the coast. The pattern of movement in the Bay will be examined in the Liverpool Bay model, which has now been satisfactorily proved.

The Severn Estuary

An investigation is being made for the Central Electricity Generating Board of the reaches of the estuary of the River Severn that lie between English Stones and the Severn railway bridge. The problems to be considered relate to the abstraction and return of the condenser cooling water of power stations, and include the following:

(1) the siting of intakes and outlets to prevent recirculation;
(2) the distribution of heated discharges;
(3) the exclusion of bed material from intakes;
(4) the effect of natural channel movements on intakes, and the effect of new works on the regime of the river; and
(5) possible general long-term heating of the estuary water.

A tidal model of the estuary is being built for the investigation to a scale of 1/480 and extensive field work is being carried out.

A second investigation is concerned with a combined inlet and outlet for cooling water. Normally, inlets and outlets are separated by a considerable distance horizontally, but in this combined structure the inlet is situated vertically above the outlet. A 1/60-model of the structure has been built and is being operated with a flow past the intake that is reversible and variable both in velocity and depth, although the full tidal cycle is not reproduced. The flow patterns are being traced with a dye, using an absorptiometer; eventually heated water will be used to produce the correct density effects.

The Wash

An investigation has been carried out on the Wash to obtain information on the natural movements of sand and silt, and on the effects of land reclamation and other similar engineering works on these movements.

Further field work is continuing with a view to determine to what extent—if any—permanent accretion on the upper foreshore is balanced by lowering of levels in the lower mud belt, and to what extent the available supplies of silt are limited. At the same time further suspended-load samples will be collected at different seaward stations in case there are additional sources of this suspended material which have not yet been detected. If there were any absolute limitation in the supplies of silt, the problems of training outfalls, drainage and reclamation would all be eased and the solution of all three might go hand in hand. The evidence so far available is inconclusive.

Portsmouth Harbour

Both the Admiralty and the Portsmouth City Corporation have under consideration, schemes for reclaiming land within Portsmouth Harbour. Before these schemes can be approved, their effect on navigational conditions inside the harbour has to be determined. The deep water entrance to the harbour is maintained by the scouring effect of the filling and emptying of the tidal reservoir, and it is important that reclamation should not reduce this effect to such an extent that adequate depths in the entrance are no longer self-maintaining . It is also important that the current patterns inside the harbour should not be altered in such a way as to cause silting in the main channels. The Admiralty therefore requested the Station to examine the possible effects of land reclamation, using a scale model of the harbour. As a preliminary to the model experiments, a study was made of records and charts of the harbour extending back to 1783; data was also collected in the field

The 1/480-horizontal scale model being used in the investigation is equipped with a fully automatic tide-generator of the pneumatic type. The tide-generator forms part of the seaward limit of the model and is located sufficiently far outside the entrance for the input tide to be unaffected by any of the proposed reclamations.

The model was first proved for current velocities recorded during a mean spring tide. Some difficulties were experienced at this stage because of the sensitivity of the currents in the harbour to minor changes in the unusual tide curve, but these were overcome and tide curves were obtained which resulted in good reproduction of the prototype current velocities.

The experiments are proceeding satisfactorily and the investigation, which should be completed by March, 1959, will be reported fully in 1959. The results obtained so far confirm that current velocities at all points are reduced by the reclamations.

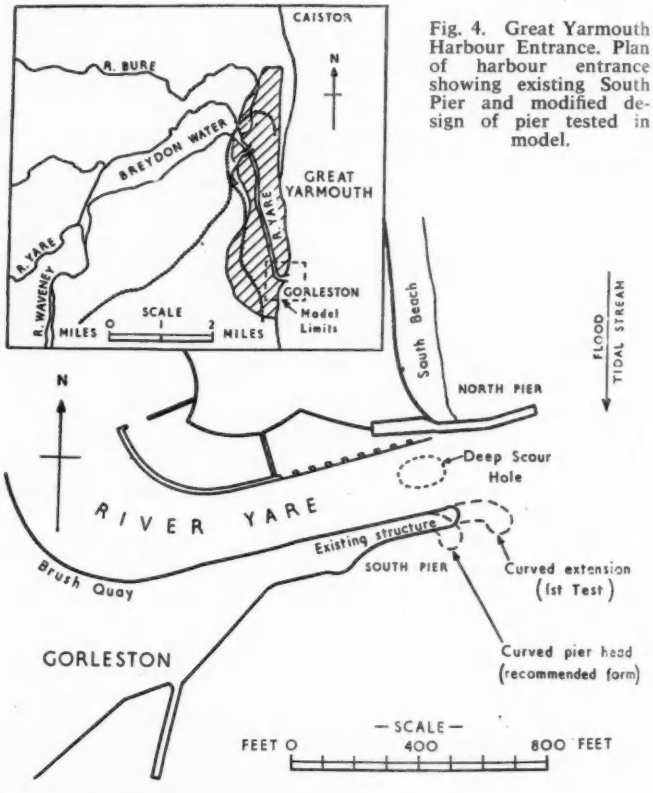


Fig. 4. Great Yarmouth Harbour Entrance. Plan of harbour entrance showing existing South Pier and modified design of pier tested in model.

Great Yarmouth Harbour Entrance

By 1949, local scour had caused a hole over 40 ft. deep to be formed in mid-channel between the two main piers, and elsewhere the general lowering of the harbour bed had exceeded the limit for which the foundations of the training works were originally designed and, once the protecting aprons were scoured away, the structures were being undermined. In addition, decay and wave action had caused further damage to the timber sheet piles and it had become necessary to rebuild most of the harbour entrance works including both the North and South piers. In the course of the design and reconstruction of the harbour entrance, the Hydraulics Research Station was consulted about the problem of preventing possible damage to the new works by further

undermining which might result if the deepening process continued. A model of the harbour entrance, including the adjoining coast line, was built to a horizontal scale of 1/120 and a simple water circulating system installed to make possible the reproduction of any combination of tidal and river currents corresponding to conditions occurring in the prototype.

Ideally, a solution to the problem of scour during the flood tide would have taken the form of a bell-mouthed entry to the harbour; this would have eliminated flow separation at the pier noses with the result that the effective flow path would have been broadened and hence both velocity and turbulence would have been reduced. However, in practice it is doubtful, for reasons connected with wave action, if a satisfactory design could have been produced based on reshaping both piers; and the North Pier had in any case already been rebuilt. A series of model tests was therefore undertaken with the object of preventing separation of flow at the end of the South Pier during the flood tide. The first experiments, made with the curved pier extension illustrated in Fig 4, showed that the flood flow followed the extension smoothly and without separation and conditions were generally less turbulent with lower flow velocities in the scour hole area. A test in the model to determine scour tendencies during the flood tide under the new conditions showed that material was carried into the hole and stayed there; and moreover, conditions further up the harbour settled down quickly, resulting in a more uniform bed than had been obtained in the tests without the extension. However, there was a tendency to scour at the foot of the curved extension and very slight scour action was observed along the north face of the South Pier.

Experiments were made with a curved pier head of the same length as the present pier but shaped like the curved extension in the first experiment. This design proved to be equally sucessful in reducing scour in the region of the hole but, as with the extension, there was some scour along the foot of the curved part of the new pier head which decreased in depth and vanished altogether where the curve joined the line of the existing pier.

The second design appeared to be acceptable as a practical and inexpensive solution to the problem, but another aspect had to be taken into account: the effects of the altered velocity and set of the currents on the behaviour of ships passing through the entrance. On the basis of the scour tests and the runs with a model ship, the curved pierhead design for the South Pier was recommended, with the rider that adequate protection in the form of aprons must be built along the curved part of the new pier head.

Port of Burnie

The Port of Burnie which is situated on the north coast of Tasmania, has expanded steadily since the first protective breakwater was built in 1889. Now, the Marine Board of Burnie are considering further stages in the development of the harbour and have requested model tests of several possible schemes.

The Board first proposes to increase the capacity of the port by constructing another pier. This will entail some dredging and reclamation and also the provision of additional protection from waves. This protection could be provided either by extending the existing breakwater—a scheme known as the Southern Development—or by constructing a new breakwater in deeper water —the Northern Development. Initially, the new breakwater would not reach the shore, but it would eventually be extended so that it was linked via a reef to the present port area. One of the purposes of the model tests is to provide information on the protection that would be provided by different lengths of the two possible breakwaters. Tests are also to be made to investigate the relative advantages, from the point of view of wave action, of two possible forms of construction for the pier—an open-piled structure. In further stages of the development of the port, the new pier might be extended and a second breakwater constructed to provide a nearly enclosed harbour. The effects of these additional works on wave action within the harbour are to be included in the investigation.

A 1/100-scale model of the harbour has been built and the tests are proceeding. It is hoped to complete the work within the next six months and to report it fully in the Annual Report for 1959.

Reconstruction of Transit Sheds, Royal Albert Dock, Port of London

During the past three years, the Port of London Authority has been engaged in the modernisation of the transit sheds serving the Royal Docks. The long straight quays at this Group are ideal for the placing of vessels, but the sheds were constructed in the days when rail transport was predominant. As a result, the necessity for serving a large number of sheds by rail from one direction has caused severe restrictions to free access by the increasing number of road vehicles.

The lay-out of the north side of the Royal Victoria Dock has overcome this difficulty by the provision of a number of feeding points on the railway system, but the existing lay-out of the Royal Albert and King George V Docks is such that similar methods cannot be applied. The original transit sheds built in 1870/1880 have two serious disadvantages; firstly, they are now not long enough for modern vessels and, secondly, the distance between the sheds is totally inadequate for modern road transport. With the modern road vehicle, which may now reach 35-ft. in total length, only half of the platform space between sheds can be served at one time.

In 1956 the first experiment was made with the conversion of Nos. 25/27 Sheds into one berth. These two sheds, operated by The New Zealand Conference Lines, were particularly suited for this purpose. The opening between these sheds was increased in width and raised to a minimum height of 29-ft. 6-in. The sheds were connected by a loading platform 35-ft. wide at which up to 12 vehicles could be accommodated at one time. This method of serving the two sheds had one serious disadvantage in the necessity for paving a large area of the railway tracks to enable vehicles to back on to loading platforms at right angles to the quay. It has proved that such a system if continued throughout the whole of the north side of the Royal Albert Dock would restrict railway operations to an unworkable limit.

Overall view of the reconstructed sheds at Royal Albert Dock.

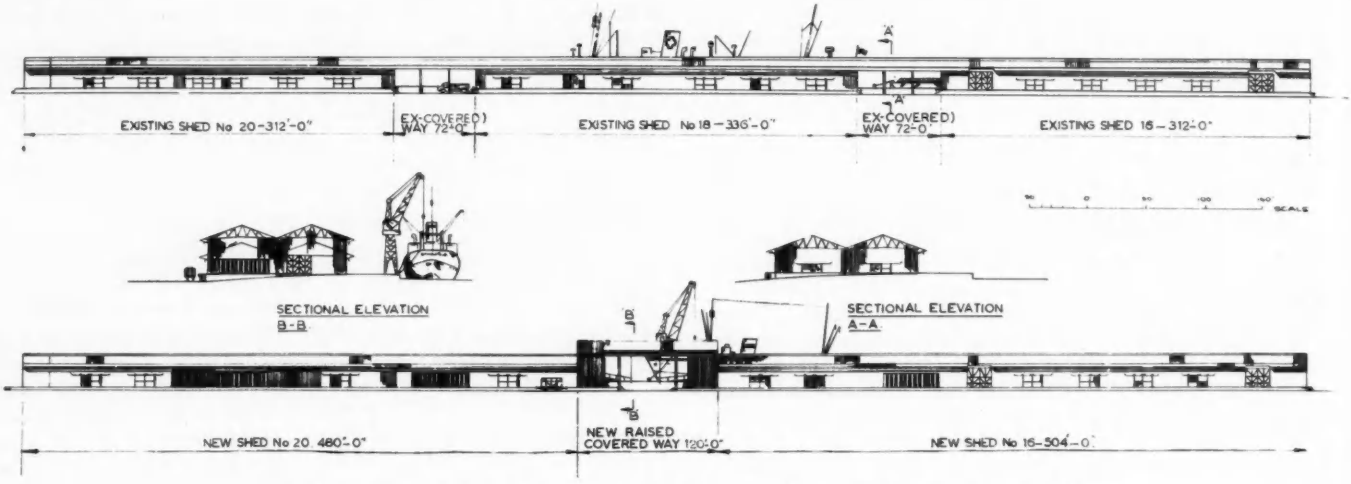
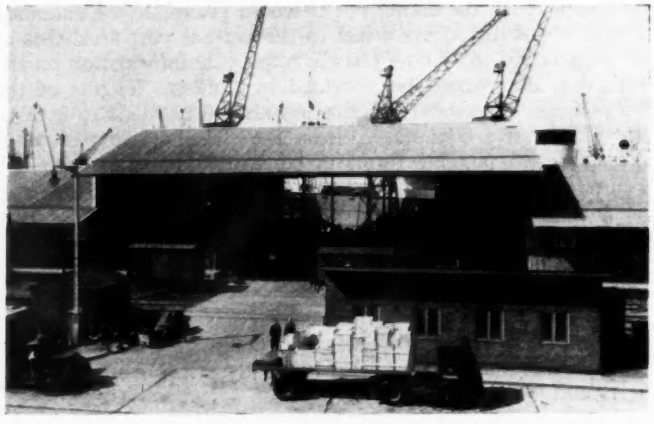


Fig. 1. The sheds in their original form (above), and the completed conversion (below).



Raised portion of the sheds showing covered way and through passage to ships

A second scheme was tried at Nos. 21/23 Sheds. The sheds were cut back in a similar manner to the previous scheme but with the loading platform at right angles to the quay, giving a distance of 100-ft. clear between loading platforms. These loading platforms are provided with folding doors 48-ft. 6-in. clear in width by 12-ft. 6-in. high, giving the maximum space available for trucking. The paving across the railway track was limited to 30-ft. as originally but the removal of the columns in the approach gave sufficient room for the vehicle to manœuvre and back to the platform. In this scheme the roof of the shed was unaltered and mobile cranes cannot use this area for unloading as in the first scheme. These two original schemes both had considerable merits. The third scheme, which is now in operation on the south side of the Royal Albert Dock, is a combination of the two previous experiments.

The first two schemes consisted of improvements to existing openings, but did not alter the relative lengths of sheds in use at each berth.

On both the north and south sides of the Royal Albert Dock 11 transit sheds serve eight berths. In consequence, it is generally necessary to use more than one shed per vessel, and the difficulties arising from this transfer of cargo cause a great deal of aditional work to the Operating Department. The original sheds are between 300 and 350-ft. long and it is necessary to use approximately one and a half sheds per berth.

In the third scheme, it was decided to convert the existing three sheds into two with a covered way, 120-ft wide, driven through the centre of No. 18 shed and raised to a height of 30-ft to eaves. The old covered ways were closed up and absorbed into Nos. 16 and 20 sheds respectively. Six large, 48½-ft. wide, collapsible gates have replaced the old, smaller doors: the result is that the three out-of-date sheds have been transformed into two modern sheds, approximately 500-ft. long, speeding up movement and capable of dealing with the many variations of present day traffic. Figure 1 shows the sheds in their original form and with the conversion completed.

The original construction of the sheds was wrought iron roof trusses, purlins and plate girders. The stanchions were hollow, round, cast iron and used as down pipes from the gutters. The external sheeting was fixed on timber framing and the covering throughout was in 18 gauge, galvanised, corrugated sheeting. The glazing was cast glass in iron astragals with zinc flashings.

During reconstruction of the sheds opportunity was taken to re-floor in concrete, re-sheet and re-glaze. The sheeting for the sides of the sheds and also for the canopies was carried out in 18 gauge, galvanised sheeting as previously, as this was found from long experience to be the best material for standing up to the rough usage to which these sheds are subjected from traffic and cranes.

The roof was re-sheeted throughout with Rigidal aluminium sheeting and the glazing was replaced with patent glazing in wired cast glass in aluminium bars. The original gutters were cast iron and it was found that many of them could be re-used. All new guttering was made to the same pattern.

Additional aprons have been provided across the rail track for lorry access and the wider doors allow additional gangs of dockers to handle goods simultaneously, while the extra height in the covered way allows for the operation of mobile cranes and also provides, as previously, direct access to the dockside for lorries to deliver direct to ships.

It is of interest to note that almost all of the wrought iron was in excellent condition and, despite being dismantled and re-erected, very few replacements had to be made.

New steel required to heighten the covered ways amounted to only 64 tons. These sheds have been in continuous operation throughout the past 77 years and illustrate the great flexibility that construction of this type gives.

The work was carried out by Harland & Wolff Ltd. and John Mowlem & Co. Ltd., to the instructions of the Chief Engineer of the Port of London Authority.

A New Development in Current Meters

Device for Simultaneous Plotting

By A. J. WOODS and D. H. MACMILLAN

FOR a very long time Hydrographic Surveyors, Hydraulic Engineers and Conservancy Officers, have been looking for a reliable current meter that would enable an observer in a tautly moored surface ship to plot a relatively simultaneous profile of accurately determined directions and rates of water movement, at a series of selected depths within relatively short intervals of time.

In general it may be said that a number of devices using propellers, anemometer type "buckets," and others using the principle of angular displacement, have achieved fairly accurate estimates of the rate of flow, but none have hitherto enabled an observer to determine direction or "set" to closer than 10°, due, of course, to limitations inherent in the ordinary magnetic element.

Furthermore, the inevitable delay in interpreting the results at each selected depth has, hitherto, made it impossible for an observer to obtain accurate results, say, within a period of five minutes, for a number of depths between surface and sea bed.

In gauging river or estuarine flow for estimation of volume of transfer, it has for long been a crying need to be able to plot direction and rate of flow as nearly as possible simultaneously for a series of depths at stations selected across a given channel section. It is certain that any reliable device that makes this possible will have an assured future in hydraulic research when performance is confirmed. It is essential in such work that field data should be precise and instrumentation has not yet kept pace with ideal requirements, especially in model work.

Naval Hydrographers, knowing the limitations of mechanical devices for tidal stream measurements have found in the behaviour of the vertical current spar of uniform section, immersed to 30-ft. depth, the best practical method for ascertaining values affecting ships whose draughts approximate this figure. The tidal stream stations shown on Admiralty charts accordingly give information based on such determinations at intervals referred to the times of high water at the nearest standard ports.

The writers accordingly decided to carry out trials near the postion of Calshot Light Vessel, at the entrance to Southampton Water, using the new direct reading current meter designed and made by Kelvin Hughes, and arranged for observations to cover continuously, and at short intervals, **two** consecutive Spring tidal cycles of equal range monitored during daylight hours by vertical spar observations.

The mean depth of the spar used was 12-ft. (or half the immersed depth) and the current meter was set to operate at 15-ft. depth; it was, of course, realised that the results were not necessarily comparable, as a mean performance over a 24-ft. depth range might not accord precisely with the behaviour of a thin layer at, or near, its mean depth.

The observing ship was moored tautly in a position 146° (True) from Calshot Castle (Centre △)—5,600-ft.—in a depth of 38-ft. at low water springs (Fig. 1).

Continuous readings at the depths given were commenced on Wednesday, 22nd April, 1959, and the following criteria for judging results were decided upon:

(a) The result covering the **two** tidal cycles (one superimposed on the other for comparison) and plotted in time in relation to the occurrence of local low water at Calshot (a fairly sharp inverted peak occurring at this time) should compare favourably if the instrument is consistent in behaviour and readings accurately taken. This, of course, pre-supposes equal tidal ranges and similar weather conditions. Fortunately the latter were consistently ideal.

(b) The curves of direction and rate should, when plotted, show consistent rates of change throughout, and not require much "smoothing," thus illustrating the tolerances to be expected in the practical use of the instrument.

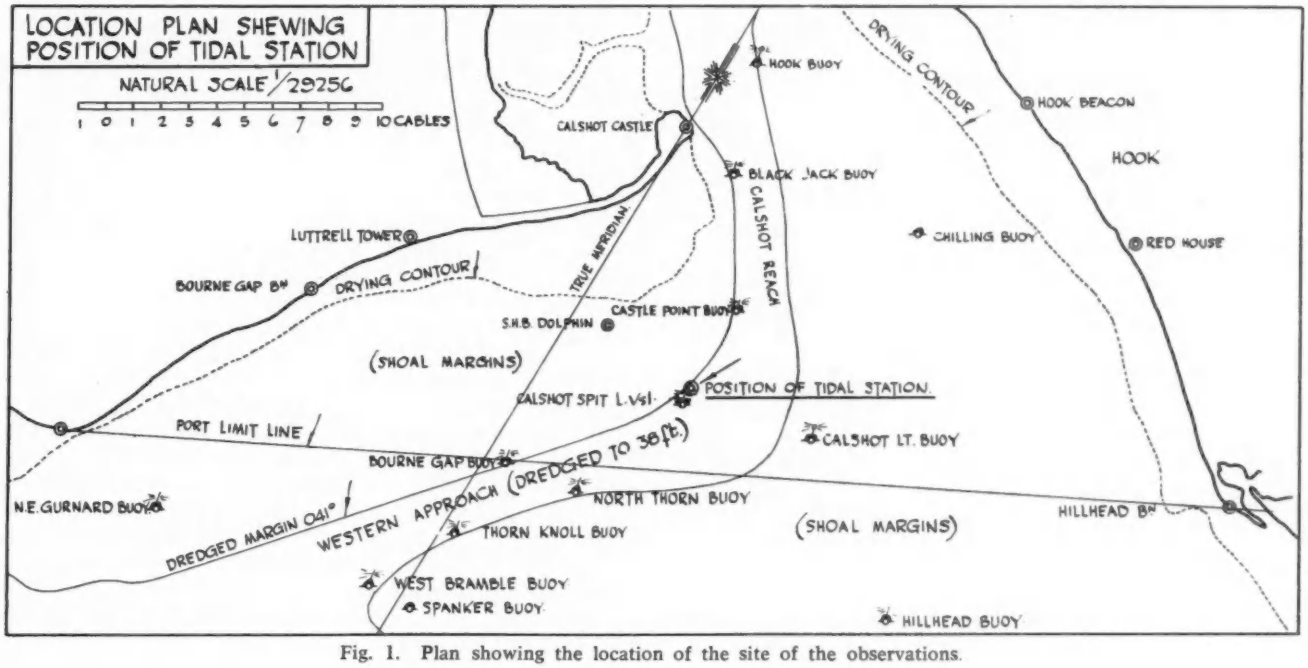


Fig. 1. Plan showing the location of the site of the observations.

(c) The spar determinations should show good approximate agreement with instrumental results in rate, and also in direction, after correcting the magnetic readings for local variation (in this case 8½° W.).

(d) The recorded features should show consistently and correctly over both cycles—i.e. over 25½ hours— the hydraulic peculiarities characterising local estuarine flow at the site. It should be remembered that the Calshot area stands in a zone of transition between the tidal regime in Southampton Water, which is strictly in phase with local tidal rise and fall, and that obtaining in the Solent axis which is not, but depends absolutely on the hydraulic "balance" between the altering sea levels at the eastern and western entrances of the Solent, that is at Spithead and the Needles, respectively.

(e) It was decided not to take profiles of rates at different depths on this particular trial, but rather to anticipate this procedure at a later stage by experiments to ascertain the practical seamanship necessary for best results in handling the new instrument.

The console, which is very simple in presentation, was mounted without difficulty in the survey ship, and the meter suspended from a yard-arm rigged in crutches athwart the deckhead plotting cabin.

It was found that reading at intervals of five minutes, or even less, could be delegated to an intelligent seaman after the simple adjustments and switching were mastered, no skill whatever being needed either in manipulation, or interpretation, as the dial indications in speed and rate appeared in a very obvious and uncomplicated manner. Incidentally, the spar observations are much more complicated, and required experience and surveying skill for accurate determinations. The direct reading meter merely required a knowledge of the few switch controls, ability to make two dial readings, and a log book in which continuous readings of direction and rate could be recorded in comfort, and without any exposure to weather. Had readings over, say, five minutes, and at five-foot depth intervals, been required, this would present little difficulty after the necessary rig had been perfected.

The accompanying diagram (Fig. 2) shows all the resulting data, plotted and presented for ready comparison. This is very consistent, and appears completely to confirm the performance claimed for this instrument.

The following two features will be especially noted in the plot of all the relevant data:

(a) The two curves provided by the instrument in relation to low water at Calshot, although taken on successive cycles are, in fact, almost identical in shape and general features, thus indicating the consistency of the two sets of observations under the same hydraulic conditions.

(b) The large circles in the diagram indicating the accompanying results of the spar drifts show very reasonable conformity with the independent results of the instruments on both tidal cycles, both in direction and rate.

It is also interesting to observe the relation of the Hurst and Portsmouth vertical curves plotted at the top of the diagram in correct time relation to the tidal stream observation.

It is interesting to note also the peak of maximum velocity occurring for a short period near 1½ hours before low water at Calshot, as well as the rapid change in direction of the tidal stream close to the instant occurring soon afterwards when the Portsmouth tidal levels begin to fall below those at Hurst. The reason for this peak is the coincidence of the West-going tidal stream with the maximum out-flow from Southampton Water, which occurs 1¾ hours before low water at Calshot.

The alteration later of the direction of the tidal stream from East-going to West-going occurs rather more slowly after the rising levels at the Portsmouth entrance overtake those at the Hurst Narrows.

If all the features in the diagram are taken together, it will be seen that they show very consistent harmony between the behaviour of the vertical and horizontal water movements.

Incidentally, it would be very easy to miss the sharp peak above mentioned occurring for a short period near 1½ hours before low water at Calshot, without the aid of this instrument, which enables the co-ordinates of the curve to be plotted so intimately; the spar observations, in fact, do very nearly miss it altogether.

The result of all these observations and conclusions demonstrate the unprecedented consistency and ease with which the direct reading current meter can be used, to give a full delineation of the tidal movement.

In addition, if observations at different levels below the surface are included, this can be achieved with ease and greatly improve the accuracy with which the transfer of water movements might be estimated.

Technical Description

An account of these tidal measurements and their implications would be incomplete without a description of the principle instrument employed. This current meter was one of a few pre-production models of the Kelvin Hughes new direct reading current meter whose inception came about in this way. An extensive review of existing methods of current measurement showed that the most commonly used instruments measured only the amount of water flowing by over a given period of time from which the average speed could be computed using a graph or calibration table. Many current meters needed to be hauled to the surface to be read. Some needed to be started and stopped by the sending of messenger weights down the suspension wire. Others needed the operator to count clicks in a telephone earpiece against a stop watch, and a few gave their results in the form of a tape which had to be interpreted to get the speed of flow. There was a real need for a current meter which would show the speed of flow directly on a dial.

A meter was accordingly constructed consisting of an underwater gear and an indicating unit, showing the speed on a dial of a micro-amperemeter.

This was tried out in the water of the Thames Estuary, and found to respond very rapidly to changes in the speed of the water. The movement of the pointer was very lively, especially when the meter was near the bottom, when it seemed possible to detect the turbulence of the water rolling over bottom obstructions. It was realised that this rapid response would be useful, but that, for some purposes, a slow response would be preferred, and a damping control was accordingly added to give more damping when needed.

Having achieved direct reading of speed the next step was to attempt direct reading for direction of flow also. The firm of Kelvin Hughes have, for many years, made gyro-magnetic compasses for aircraft in which the gyro is monitored by the signals from a sensitive magnetic device placed in a good magnetic situation, for example, in the wing tip. This element is called a "Fluxgate," and has been developed to a very high degree of reliability. One of these units was then mounted in the underwater part of the new current meter and the necessary circuits built into the indicator unit. It was found possible to correct the magnetic deviations so that they amounted to less than one degree, and, assuming ordinary accuracy of construction of the underwater gear, it could be safely assumed that the direction of flow indicated would not in practice have an error greater than

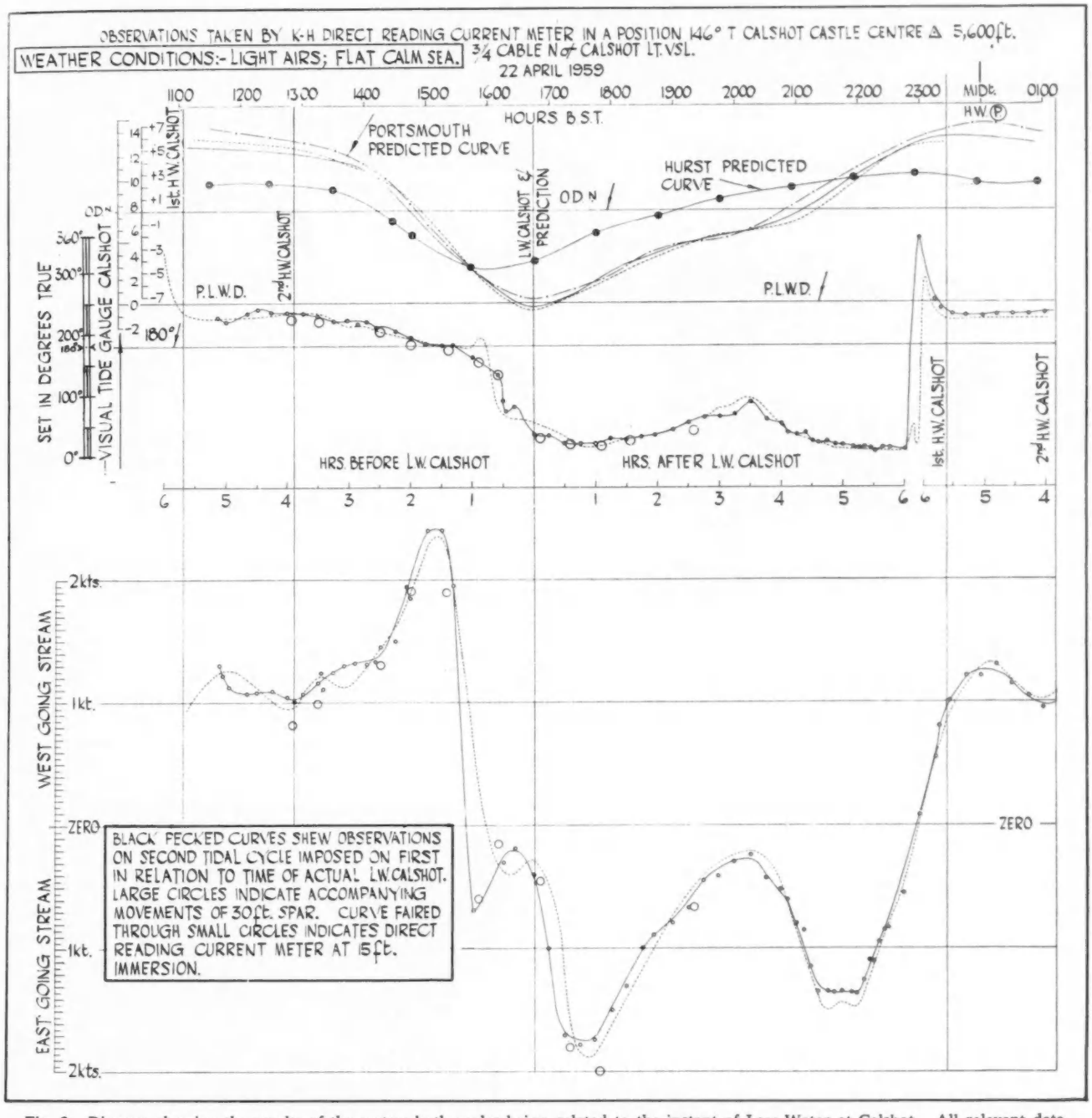

OBSERVATIONS TAKEN BY K-H DIRECT READING CURRENT METER IN A POSITION 146° T CALSHOT CASTLE CENTRE Δ 5,600ft.
WEATHER CONDITIONS:- LIGHT AIRS; FLAT CALM SEA.
¾ CABLE N of CALSHOT LT.VSL.
22 APRIL 1959
HOURS B.S.T.
PORTSMOUTH PREDICTED CURVE
HURST PREDICTED CURVE
L.W. CALSHOT & PREDICTION
1st H.W. CALSHOT
2nd H.W. CALSHOT
P.L.W.D.
SET IN DEGREES TRUE
VISUAL TIDE GAUGE CALSHOT
HRS. BEFORE L.W. CALSHOT
HRS. AFTER L.W. CALSHOT
WEST GOING STREAM
EAST GOING STREAM
2kts.
1kt.
ZERO
BLACK PECKED CURVES SHEW OBSERVATIONS ON SECOND TIDAL CYCLE IMPOSED ON FIRST IN RELATION TO TIME OF ACTUAL L.W. CALSHOT. LARGE CIRCLES INDICATE ACCOMPANYING MOVEMENTS OF 30ft. SPAR. CURVE FAIRED THROUGH SMALL CIRCLES INDICATES DIRECT READING CURRENT METER AT 15ft. IMMERSION.

Fig. 2. Diagram showing the results of the meter; both cycles being related to the instant of Low Water at Calshot. All relevant data, bearings and checks are shown.

1½ degrees. This accuracy of direction measurement is much superior to that normally attained with current meters. The reading of the new current meter, "D.R.C.M." for short, is very simple and rapid, and does not need the attention of specially skilled people. After switching on the left-hand dial quickly and directly shows the speed. The centre dial will show an imbalance to one side or the other (Fig. 3). The knob beneath the right-hand dial, having been pressed and turned until the centre dial pointer shows somewhere near the centre zero, the pointer on the right-hand dial gives the "magnetic" direction of flow, that is, the angle between the direction of flow and the local magnetic meridian, to the degree of accuracy mentioned above.

The underwater gear (Fig. 4) consists of a central fish-shaped body which bears four guards which serve to support the forward propeller bearing, and to protect the propeller from damage. The tail of the meter is conical in form, and is made of perforated aluminium coated with a plastic paint. It has been found that this conical tail causes the axis of the meter to stream in the current very accurately, whereas it is common for other current meters to yaw badly at the higher speeds. In spite of this good streaming the drag is very little greater than is experienced, for example, with the Roberts current meter with its tail consisting of four fins intersecting in a cross. The propeller runs in low friction

bearings made of "P.T.F.E."—Polytetrafluorethylene—which is an excellent material for bearing where, as in the present application, there is abundant cooling water. The body of the meter is completely sealed, and is filled to capacity with oil. A metal bellows takes care of changes in the volume of the oil due to temperature and pressure variations. The body contains the magnetic detector element and the necessary corrector magnets, as well as the cam and contacts for the speed measuring circuit. There is no mechanical connection between the inside of the body and the propeller. The necessary drive is by means of a magnetic

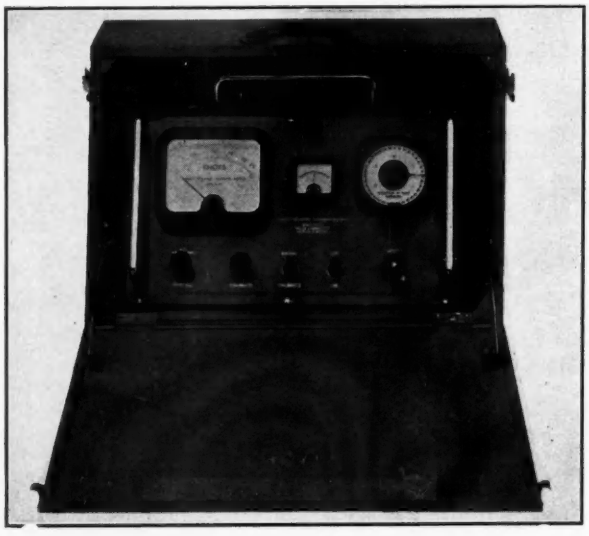


Fig. 3. Photograph showing the console bearing indicator dials for speed (in knots) and direction (magnetic).

coupling one half of which is in the propeller hub, and the other inside the body, mounted on the same shaft as the contact cam. The electrical connection is through a watertight gland at the top of the meter body. The meter is mounted on trunnions supported in a brass hanger, to which a short length of brass chain, with the required length of supporting cord, is shackled. The meter is balanced to remain horizontal in waters of different densities, by an adjustable balance weight provided in the tail.

The indicator unit is connected to the underwater gear by a length of 6-core screened cable. All the electric power required comes from ordinary dry batteries mounted in the back of the unit, the whole gear being entirely self-contained and independent of outside power supplies. It can therefore be used anywhere. The first prototype was used at Halley Bay in the Antartic. Immediately afterwards it was sent to the Persian Gulf where it performed very well, and, because of its rapid and direct method of use, saved a lot of observer's time. The rotation of the propeller, driving a contact arm, causes intermittent electric pulses to operate a relay in the indicator unit. This controls a circuit which ensures that the voltage across a capacitance depends on the speed of recurrence of these pulses. The meter measuring this voltage is then scaled in knots in accordance with the results obtained from tests in a ship tank at various constant speeds.

The direction sensing device—the "Fluxgate"—consists of two elements mounted parallel to the axis of the current meter and two elements across the axis. All four elements are mounted on a frame suspended from gymbals, and are consequently always horizontal. The signals from these two pairs of elements depend upon the angle which they make with the earth's magnetic meridian, and are eventually fed to a resolver. When the resolver rotor is turned until a balance is achieved, as shown on the centre meter, the direction pointer, which is fixed to the rotor, will then indicate on the circle the direction towards which the water is flowing. Supposing the water is flowing to 045° magnetic a balance could also in theory be obtained at 135° magnetic. In practice, however, this ambiguity of reading is prevented because the indicator unit contains an amplifier which feeds a signal to one or other of two solenoids depending on the phase of the signals from the magnetic detector. These solenoids operate ratchets on a gear wheel connected to the direction pointer, which are so set as to prevent the setting knob being turned in any but the correct direction to find the true null position, and thus the proper direction reading. When the pointer is only a few degrees on either side of the correct reading the amplified signals are too weak to operate the ratchets, and the operator can make his final setting in the usual way by moving the knob a little in either direction until the small meter indicates balance. Although this sounds very involved it is not so. Readings of speed, direction, and time, can be made and written down at intervals of as little as one minute, if desired.

Because of the simplicity and rapid reading of the D.R.C.M. it can be used for taking a profile of the water speeds and directions at different depths. When the flow shows little change readings can be infrequent. When conditions begin to change quickly readings can be taken very frequently. Because the speed device is entirely independent of the direction unit, the direction of flow can still be obtained accurately, even when the current is too slow to turn the propeller. This occurs at a little over 0.10 knots.

Referring to the illustration of the plot of the results obtained at Calshot, some points surrounded by little circles will be seen. These indicate results which were obtained with a vertically floating wooden spar, 30-ft. long, of which 24-ft. was immersed. The speed of drift of this spar was obtained by measuring the length of calibrated distance line run out in one minute. The directions were obtained by sextant angles between the spar and known landmarks. Although it does not necessarily follow that the drift of such a spar will correspond exactly with the indications of a current meter at 15-ft. depth of immersion, yet the agreement in

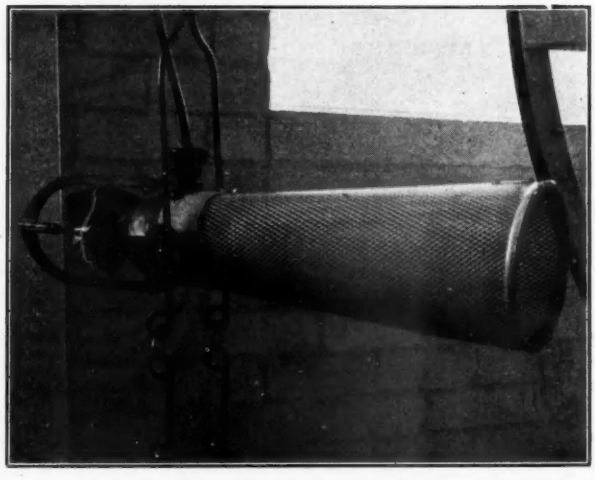


Fig. 4. Photograph of the underwater unit.

direction and rate shown in these experiments is really striking and confirmatory. The current meter can, of course, give readings much more frequently than those obtained from the spar, and, if desired, it can be hauled up, or down, to give readings at several depths nearly simultaneously.

Ship Design for Efficient Cargo Handling

I.C.H.C.A. Meeting in New York

Early this year a symposium dealing with the above-mentioned subject was held in New York under the auspices of the International Cargo Handling Co-ordination Association. Eight papers were read during the proceedings. 'Special' ships, such as bulk carriers and cargo container vessels, formed the subject of four of them. A fifth, by Professor L. M. Tichvinsky, on "Cargo Handling Research in U.S.S.R.", was of a purely technical and analytical character.

It is true to say that in general terms the various papers tended to emphasise that different traffics and different types of cargo call for different types of vessels—even general cargo vessels. Perhaps two of the most interesting papers were those on "The effect of machinery aft on cargo handling" and "Economical cargo space for break-bulk freighters". As is confirmed by the extracts printed below, these subjects were most controversial.

The Effect of Machinery Aft on Cargo Handling

By HENRY J. KARSCH
(Project Manager, J. J Henry Company, Naval Architects, New York)

In recent years a considerable amount of attention has been given to improvements in the loading, discharging and stowing of cargo aboard general cargo type vessels. The various means considered and used include improved cargo gear, modernised winches, revolving and gantry cranes, containers, mechanical and hydraulic hatch covers, flush hatch covers for utilizing motorised cargo handling equipment below deck, the roll-on roll-off principle, twin hatches, triple hatches, etc. These improvements are chiefly of a mechanical nature involving the vessels' equipment. A further but by no means unimportant consideration involves a major change in the vessels' arrangement, and consists of placing the propulsion machinery aft. This is not a new idea. Many cargo vessels have been designed and built that way, but the general trend is to place the machinery midship.

The principal arguments offered in favour of the machinery midship location are the absence of great variations in a vessel's trim between light and loaded conditions; the favourable location of the navigating bridge with respect to visibility and access to all parts of the vessel; the more spacious and better arranged engine room obtainable; the greater amount of space available for the crew accommodation; and the lesser weight of the vessel's hull structure. These so called advantages of the machinery amidship location over the after location can easily be overcome technically and practically. Perhaps the strongest argument to overcome is the one that cargo vessels usually and traditionally have their machinery placed midship.

The strongest objection to machinery aft cargo vessels is the excessive trim that may result in the lightly loaded conditions. This objection is not too serious in those trades where a suitable quantity of cargo is carried in both directions, where the prevailing weather conditions are not too severe, and where draft limitations are not encountered in the ports of call. The trim problem is greatly lessened in the modern high speed vessel whose longitudinal centre of buoyancy is placed aft of midship in order to obtain the most favourable propulsive efficiency. By planned bunker and cargo stowage, and the use of a reasonable amount of water ballast in double bottoms and deep tanks placed in the otherwise unusable narrow forward hold, a favourable trim can easily be achieved. The use of deeper bottoms for increased ballast capacity is not necessary and is in fact detrimental to stability in the loaded condition and reduces cubic.

Machinery aft vessels will on the other hand, tend to trim by the bow when fully loaded with homogeneous cargo. To overcome this, the poop can be extended forward over the aftermost hold, thereby not only correcting the trim but also providing additional cargo cubic, a vital requirement for today's general cargo.

On vessels with machinery aft the crew is usually berthed aft and the navigating bridge placed aft, midship or forward, depending to a great degree on the vessel's size and type of cargo gear it is fitted with. The after location is recommended on smaller vessels. On larger vessels, when clear decks are required for cargo handling equipment such as gantry cranes, the after location is also recommended, except in those instances when the cargo gear interferes wih vision over the bow, in which case an extreme forward location may be chosen. The extreme forward location, however, is exposed to damage from heavy seas. A narrow detached bridge containing the navigating spaces with or without deck officer accommodations frequently placed midships. This location is usually chosen on larger vessels to overcome the impaired visibility from aft when fixed masts or kingposts are used for handling. Revolving cranes provide minimum interference with visibility and permit locating the bridge aft on even the largest vessels. In all cases when the navigating spaces are contained in a detached bridge midship or all the way forward, the main disadvantage is the "hardship" of the forward watch having to walk aft for meals or sleep.

With regard to the availability of more ample and suitable space for both machinery and accommodations in the midship location, this cannot really be considered a justified reason for placing them there. The main purpose of the vessel is to carry cargo, and the best spaces should be allocated to this pupose. Machinery placed aft will occupy more of the vessel's length, but less of its precious volume. It is important, however, the minimum length be used for the engine room and that its layout be carefully planned Diesel propulsion plants will generally require greater length than steam turbines. There is no difficulty housing the crew aft when part of the crew is placed in a detached bridge house forward, but if all are to be accommodated aft, again careful planning is necessary.

Vessels with machinery aft must be designed with increased section modulus, but this, at most, amounts to a few hundred tons less deadweight. This is unimportant to the general cargo vessel to which cubic is the more important factor. Longitudinal framing is more readily adopted on the machinery aft vessel and this will reduce the deadweight difference.

Vessels with machinery aft have a number of distinct advantages which more than overcome their curable disadvantages. These include greater cargo cubic capacity, more usuable cargo space, more uniform hold lengths, more unobstructed weather deck space for deck cargoes and special cargo gear, wider and more deck area, and greater suitability for roll-on roll-off and lift-on lift-off use, and for twin or triple hatches.

The gain in cargo cubic resulting from placing the machinery aft has usually been referred to as a "slight amount" or "about 5%". The cubic gain can, however, be considerably more. For the purpose of obtaining a realistic appraisal of this gain, two basic C3 type cargo vessels of identical dimensions and total volume were compared.

Mr. Karsch went on to explain that the result, based only on cubic below the main deck (i.e. cubic space usable for general and liquid cargo), was a gain of about 11%. Further, he produced an illustration comparing the same two basic C3 type cargo vessels, identical in dimensions and in total volume, but which were actually under construction. "The gain in this case" he said, "amounts to over 14 per cent." This gain is greater than in the basic vessel comparison partly because the actual machinery midship vessel does not use all the potential cargo

cubic available. A still greater gain is realised if the cubic in the poop over the aftermost hold of the machinery aft vessel is included.

The gains are realised chiefly due to the smaller volume occupied by the engine room and the elimination of the shaft alley.

The ideal square space occupied by the engine room of the machinery midship vessel is used to better advantage for cargo on the machinery aft vessel. Spaces normally too narrow for efficient cargo handling and stowage such as the shaft alley recess and deep tanks (unsuitable for liquid cargo) in the after end of the ship are included in the engine room on the machinery aft vessel. Holds No. 4 and 5 on the machinery midship vessel are seriously impaired for handling cargo due to the presence of the shaft alley. This condition does not exist on the machinery aft vessel, in which more uniform hold lengths are obtained.

It is a debatable question whether deck area should be used for decks or hatches, but in either case there is more deck area available in the machinery aft vessel. Greater area is available even though the hold length is shorter, accountable, due to the greater mean width of the decks brought about by the elimination of the fine after end of the vessel as cargo space.

Machinery aft is a prerequisite for installing two or three hatches abreast instead of one hatch per hold. With the machinery midship it would be difficult to obtain the proper structural continuity of the longitudinal bulkheads usually employed with multiple hatches without seriously impairing the machinery space. Multiple hatches, particularly triple hatches, are less feasible in a machinery midship vessel because of the lack of width in the tween decks and holds in vessel's after end.

The carriage of vehicles and wheeled containers, which is again being encouraged, is best suited to a machinery aft vessel. Whether the vehicles are lifted on or rolled on through side ports, there is a continuous deck on all levels uninterrupted by the engine room. The wider, squarer, and greater deck areas favour easier stowage and a greater number of vehicles. The same benefits apply to the carriage of lift-on lift-off containers. In addition, should the navigating bridge be placed at the extreme forward or after end, the gantry cranes have the full run of the weather deck, permitting a more flexible arrangement. A third gantry, if desired, can be installed, augmenting both forward and after holds instead of being confined to one end.

Economical Cargo Spaces for Break-bulk Freighters

By S. A. VINCENT

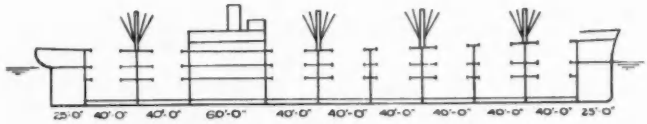
(Consulting Naval Architect, Newport News Shipbuilding and Dry Dock Company)

The principles of design discussed in this paper were based primarily on the assumption that when two gangs work in a hold they interfere with each other sufficiently to reduce their normal outputs by 20/30 per cent.

Mr. Vincent opened his paper by stating that two basic classes of operational cost are involved while a merchant freighter is in port discharging and loading break-bulk mixed general cargo. One, he said, is principally for stevedore pay and dunnage but also includes miscellaneous charges such as for pilotage, tugs, running lines, wharfage, watchmen, clerical and tallymen services, etc. For brevity such expenses will be referred to as the "cargo handling costs." The other is the in port cost of depreciation and interest for the ship, stores, subsistence, maintaining and manning the ship, overhead, fuel consumed in port, insurance, etc. These costs will be referred to as the "ship costs." Each of these two classes of expenses costs several thousand dollars a day for a sizeable American freighter. For normal-speed freighters, the daily "ship costs" while in port is not much less than when steaming at sea. The principal difference is the fuel cost, only a few hundred dollars per day. The following proposal should result in substantially reduced "cargo handling cost" with not more and usually less turn-around time, so equal or less "ship cost" while in port. Shorter time in port results in more voyages and, therefore, more cargo transported annually.

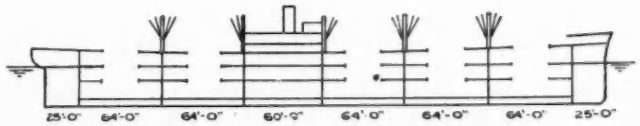
Basically it is proposed that the hold size be reduced enough to permit a single stevedore gang to handle one hold or cargo in the same or less time than a double gang in a conventional larger size hold. The reduced hold size is arranged to permit stowing of long lengths of steel, pipe, etc., as in conventional holds. No unproven design or equipment problems are involved. The propulsion machinery space may be either amidships or aft whichever is preferred.

Double gang cargo handling, two groups of stevedores separately working the same hatch, involves interferences with each other, also, both gangs justifiably often stepping aside when either gang's cargo is suspended overhead. At best, stevedore injuries are a serious and costly problem. Single gangs, half the number of men, do not have such interferences and only step aside when their own cargo is overhead. Twin hatches abreast, instead of one hatch longer athwartship than fore and aft could



430'- SHORT HOLD - SINGLE GANG TYPE

8 PAIRS OF BOOMS (OR 8 CRANES)



430'-NORMAL HOLD - DOUBLE GANG TYPE

8 PAIRS OF BOOMS (OR 8 CRANES)

be used but this would involve the same interferences and, also, step aside inefficiency for the pierside hatch unless, as occasionally develops, both sides of the ship, pier and barges, are used in transferring cargo. Experience with twin hatches abreast serving deep tank spaces that are also used for dry cargo has demonstrated this.

Experience in many ports shows that although cargo handling efficiency varies with the class of cargo and conditions, the quantity handled per man-hour by double gangs is usually from 70 to 80% (rarely over 80%) of that for single gang stevedoring Thus for 100% more stevedore pay, a double gang handles only 40 to 60% more cargo per hour than a single gang. This reduces port time which, in the case of ships with conventional large capacity holds, may save enough "ship cost" to offset the increased "cargo handling cost."

To provide the cost saving of single-gang stevedoring and equal, or less port time, I propose single-gang midship holds about 40-ft. long with boom cargo handling gear located only between alternate hatch ends. The end holds might be longer than 40-ft. as discussed below. Sizeable freighter holds average at least 64-ft. long. Subdivision and other factors result in some variation in the hold lengths in a conventional ship, but 64-ft. is conservative and will be used in the following. (see illustration).

The cargo in the proposed single-gang 40-ft. hold would be handled in the same length of time as a 64-ft. double-gang hold

if the double gang handles 60% more cargo per hour than a single gang. The stevedore pay would be 20% less per ton of cargo for the 40-ft. hold type and the "ship cost" would not be affected. If the double gang handles only 40% more, the cargo handling time would be 12½% less than that for the double-gang 64-ft. hold. The stevedore pay would be 30% less per ton of cargo for the 40-ft hold type and the "ship cost" would be 12½% less. If conventional holds are longer than 64-ft. the savings would be even greater. The time and pay for opening and closing hatches and for rigging gear would be the same as for conventional vessels. The relative cost figures are not presented as being exact for all conditions. Overstowed or difficult cargo in one hold may delay the ship in port. They merely indicate that substantial savings seem likely for the short hold type, with no apparent disadvantages. To give a rough idea of the saving, it would range from about $1,000 to $2,000 a day for recently built (not war surplus) typical large American freighters while in American ports, a range depending upon whether a double gang handles 40 or 60% more cargo per day than a single gang. The exact relative foreign port cost might not be the same, but the trend would be.

End holds are shaped, making cargo handling slower per cubic foot (or ton) of cargo. From a cargo handling viewpoint the ideal freighter would have holds and cargo gear that all require the same cargo handling time. Subdivision may require conventional long-hold ships to have shorter holds near the quarter length. This is not the case with the proposed short-hold type. It would likely develop that for equal cargo handling time the end holds should, or at least could, be longer that the 40-ft. suggested for the midship holds.

The optimum hatch size depends upon operating conditions. Some have perhaps shortsightedly suggested extremely large hatches, but this reduces useful wing deck area for shifting overstowed cargo, rain tents may be impractical and without them serious costly delays develop, the hatch covers are very heavy and thick reducing deadweight and cubic capacity and the cost of construction and maintenance in increased. Very large hatches permit longer lengths of pipe, etc. to be stowed in the holds. If the hatch covers are of a type that permits doing so, a portion of an unusually large hatch could be left unopened thus reducing the size of the opening and provide the equivalent of wing area. Small hatches involve greater horizontal movement of the cargo to wing areas well beyond the hatch square. Most classes of sling-handled (or the equivalent) cargo must all be moved at least 5 and usually 10-ft. to or from the sling merely to load and unload it. This is true even if accurately spot landed by cranes within the hatch square and on the pier. There would be that much horizontal movement even if the hatch is as large as the hold.

After arguing that the additional cost and time spent moving cargo in wing areas beyond 5-ft. or 10-ft. from the square of the hatch is, in any case, a very small part of the total cost of cargo handling, Mr. Vincent continued: In general, a fully loaded ship is more efficient than a partially loaded ship. Experienced operators have found, however, that under some conditions a nearly but not quite fully loaded vessel having some unoccupied cargo space area while enroute at sea may spend much less time discharging and loading cargo (both "ship" and "cargo handling" cost are involved) on a multi-port route as this minimizes costly overstowage Slightly reduced loading may earn higher dividends than if the same ship carried more cargo. Regardless, this does not justify the recent American trend of designing ships for a draft that could be assigned. Occasionally there are maximum deadweight cargoes not involving overstowage.

One pair of kingposts, or the equivalent, between alternate hatch ends will provide for single gang cargo handing, two booms per hatch. To provide ample deck space for winches the hatch ends should be between about 20 and 25-ft. apart, preferably 25-ft. Formerly 30-ft. was usual but this is no longer considered necessary. The frame spacing will control the exact distance, also the hatch size and bulkhead spacing The following is based on 30-in. frame spacing, 40-ft. hold length, 25-ft. between alternate hatch ends and 10-ft. between the other hatch ends. This results in a 22-ft. 6-in. fore and aft hatch opening. If 20-ft. is acceptable for the winch area the hatch size would increase to 25-ft. or the 10-ft. between alternate hatch ends would increase to 15-ft.

The athwartship hatch dimensions could be at least 60% of the beam without introducing structural strength problems. On this basis and assuming 64-ft. beam, the hatch could be 22-ft. 6-in. or 25 ft. fore and aft and 38-ft. athwartship to serve a hold that is 40-ft. v 64-ft. Unless there is a definite need of very large hatches, I suggest using 50 instead of 66% of the beam, the hatches being 22-ft. 6-in. x 32-ft. These hatch dimensions permit using any of the usual type hatch covers, preferably stowing them horizontally outboard of the hatches when fully opened. If cranes are preferred to booms there could be one centreline crane at each hatch end, the hatch opening being 20-ft. or 25-ft. fore and aft and 20-ft or 15-ft. respectively between all hatch ends.

The 64-ft. athwartship hold dimension and the 32-ft. to 38-ft. corresponding hatch dimension is the full equivalent of the fore and aft length of a conventional freighter's holds and hatches. Long pipe, steel etc., would be stowed athwartship in the short hold ship and the lengths that could be stowed (below deck) would be as long as could be stowed in a normal freighter. There should be provisions against long heavy units of cargo damaging the side shell if the cargo shifts during heavy weather. The shipbuilding cost should be about that of conventional freighters as the cost of more bulkheads and more but usually smaller hatches versus less cargo handling gear roughly balance out, depending upon the specific design.

There is a common and perhaps correct thought that cargo handling has gone from bad to worse since World War 1. Some blame it on the stevedores, but in my opinion it is partially due to modern ships being larger and faster. This means larger holds and more shape in the holds taking longer per ton or cubic foot of cargo load and discharge. Shaped holds slow cargo handling. The 30% or so of parallel body of the old slow ships is no longer practical due to current high speeds. By reducing the hold length to 40-ft. or so we can correct the larger hold situation. Short holds with ample wing space reduce the operating cost per ton-mile of cargo, confine a fire to a smaller cargo space and materially reduce the chances of loss in case of collision damage.

When ordering a new ship, most owners specify the deadweight, speed and draft limit. Usually they arbitrarily decide that they want a little more or less cargo capacity than some ship that they are familiar with. How do operators know that during the next 20 years their operations will require a specific deadweight? Conditions change from year to year. It would be far better to suggest an approximate deadweight, have the ship designed for economical cargo handling and accept whatever the length and deadweight is, say within 5% or so of the suggested figure. This attitude might be the difference between operating at a profit, or at a loss.

In the discussion which followed Mr. Vincent's paper, the author was asked why he did not recommend machinery aft for general cargo vessels. "If the machinery is aft in seagoing breakbulk freighters", he said, "there must usually be voluminous ballast tanks near the bow, and in some cases also well aft, to adjust the trim and draft. Considerable weight is thus concentrated near the ends of the vessel increasing the weight radius

(Continued at foot of following page)

Esso Marine Terminal at Milford Haven

Work on the new Esso Refinery at Milford Haven was commenced in July 1958 and has now reached the half-way stage in its construction. It is designed to refine 4½ millon tons of Middle East crude oil per annum and the principal products to be manufactured will be petrol, aviation turbo fuel, diesel oils and fuel oils, which will be distributed to Esso terminals in the United Kingdom, mainly by coastal tankers. The entire project is expected to cost about £18 million and to be completed by November 1960.

Exceptional care has been taken to reduce the impact of this new industrial enterprise upon an open countryside and coastline. For example, this is the first refinery in the world to have been constructed with the advice of a professional landscape architect. It is also the first refinery in Britain to be air-cooled throughout, thus eliminating the need for large quantities of sea water normally required for cooling, and thereby reducing the dangers of sea pollution by oil. Process water will pass through a skimming pond and separator before being discharged into the sea.

The Marine Terminal

Constructed in the shape of a " T," the marine terminal extends approximately 3,500-ft. into the deep waters of the Haven and is headed by two outside berths to accommodate tankers of up to 100,000 d.w.t., and an inside berth to take vessels up to 5,000 d.w.t. To minimise inconvenience and to allow local fishing craft to follow their customary inshore passage, the design allows for small ships to pass under the approach jetty within 1,000-ft. of the shore.

The general structure of the terminal consists of R.C. concrete, mainly precast, supported on more than 900 pre-stressed tubular concrete piles 27½-in. and 22-in. in diameter, some of which are over 140-ft. long and weigh about 18 tons. The fabrication of the piles, the pre-cast trestle units which rest on them and the road slabs is carried out in a casting yard sited on a hill about a quarter-of-a-mile inland on the eastern side of the Refinery (see illustration). From here the piles and units are transported to the end of a temporary jetty in Gelliswick Bay where they are loaded by a 20-ton derrick on to pontoons for transport to the permanent works. Over 110,000 linear feet of piling have been cast to date together with a total of more than 100,000 cu. ft. of the pre-cast units and road slabs.

From the end of September last, complete road access has been available to the first berth along the 3,500-ft. approach jettty and work is now proceeding on the second berth, and its approach and dolphins.

Oil Pollution Precautions

The Skimming Pond is designed to prevent possible pollution of the Haven. It comprises a reservoir in a natural ravine with a normal capacity of some 5¼ million gallons and an emergency maximum capacity of 10 million gallons. All refinery surface drainage water, and water which has previously been through the process unit separator to remove entrained oil will pass through this pond which is fitted with a dam and a skimmer to remove any oil still present. The clean water is pumped out through a 48-in. diameter effluent line into the Haven submerged below the low water mark. In an emergency, such as a tank failure, all oil will go to the skimming pond to prevent direct drainage to the Haven.

Top left: Entrance to the well-protected Milford Haven. Left centre: The permanent jetty under construction showing (off-shore end) one of the berths. Centre foreground: The temporary jetty in Gelliswick Bay and a little above (to right) site of the casting yard.

The skimming pond and skimming box have been completed and two 10,000 tons ballast water tanks have been erected into which all tankers coming to the refinery will discharge their ballast water, all of which may be contaminated with oil. After settling, the contents of these tanks are discharged to oil and water separators.

Landscape Considerations

Industrial landscaping and design has ensured that the refinery is integrated with its surroundings. By careful siting, the majority of plant and tankage is hidden within a natural ravine; that which is exposed will be painted to blend with the surroundings, and where possible, tree belts will be planted to afford a screen from the land side and the sea.

Ship Design for Efficient Cargo Handling—*continued*

(Concluded from previous page)

of gyration if there is not always a considerable load of properly distributed cargo, a rather optimistic assumption. An important result, apparently often overlooked, is that this increases the pitching motion and under some sea conditions may either initiate pounding that would not have developed in a conventional vessel, or increases the violence of pounding impact and the associated vibratory pulsations that progress from bow to stern. Consider a carpenters hammer. It will pound a nail much harder if held normally than if the same hammer is held close to its head. This corresponds respectively to two ships, one with weight concentrated near the ends and the other with the same weight nearer to amidships.

Coal burning ships usually have the fuel weight concentrated amidships. Some have been converted to oil burners and the fuel and fresh water weight distributed from bow to stern in the double bottom. It was found, and beyond any doubt, that after conversion the pitching motion was noticeably more violent. This is factual, not merely a theoretical conclusion. Machinery aft and ballast near the bow would obviously even further worsen the situation. If the double bottom is unusually deep to provide extra ballast capacity all fore and aft, then the available cargo space cubic capacity is reduced, a serious deficiency for a cargo ship. The deadweight would also be reduced and the shipbuilding cost increased. There is an old and true saying in naval architecture, "For the best motion at sea concentrate the weights amidship and spread them athwartship." Of course, if pitching motion is considered unimportant, then what I have said may not be of interest.

Statistics on Large Docks

Lloyd's Register of Shipping have issued a separate publication, dated May, 1959, giving particulars of large dry and floating docks throughout the world. There are four sections arranged as follows: (A) Docks between 900 and 1,400-ft. in length, arranged alphabetically according to port; (B) Docks between 700 and 899-ft. in length, arranged similarly; (C) Docks between 1,400 and 700-ft. in length, arranged in order of length; (D) Docks shown in the first three sections, arranged in order of breadth. The particulars given are comprehensive and are taken from Volume IV of *Lloyd's Register Book (Directory).*

New Locomotives for Manchester Ship Canal Company

THE Manchester Ship Canal Company is a statute railway company, and provides rail services to many important industrial concerns as well as serving its own dock system.

The railway is split into three sections, which are interconnected.

First From Trafford Park, Manchester Docks, Weaste to Partington. In this section, which is by far the largest, there are very heavy tonnages of iron ore, sulphur etc., disembarked at Weaste and hauled in trains of over 700 tons to Bridgewater Junction of the British Railways. This route calls for some very intensive locomotive work, about five miles of severe gradients of up to 1 in 73 and 1 in 40 on the return journey with reverse curves and constant interruption by road crossings. There are also considerable tonnages of steel, oil and general goods to deliver and and to take away from the various very large works situated in Trafford Park. At Partington there is a coal exporting installation which requires considerable tonnages daily of coal delivered by rail to tip into vessels. As well as these different items of important traffic, there is of course the general cargo for the Docks.

Second At Ellesmere Port there is a considerable amount of general cargo to be handled with gradients of up to 1 in 55.

Third At Stanlow many hundreds of empty rail tank wagons have to be delivered from the British Railways by the Manchester Ship Canal locomotives to the various refineries and block trains of loaded wagons despatched over gradients of up to 1 in 64 on the Canal Company's railway to the British Railways main line.

The Canal Company have heavy steam locomotives with 18-in × 26-in cylinders handling this traffic but as some of these were reaching the end of their useful life and it was desired to take advantage of the economies provided by Diesel locomotives, it was decided that they should gradually be replaced by the latter. Two diesel electric 0-6-0 type locomotives "Alnwick Castle" and "Arundel Castle" designed and built by Hudswell, Clarke & Co. Ltd., Leeds, in close collaboration with Brush Traction Ltd., (now Traction Division, Brush Electrical Engineering Company Ltd., Loughborough) were therefore recently supplied to the Company (See Fig. 1).

Specified Locomotive Performance

From a survey of the Canal Company's track and traffic requirements, the most severe duties which the locomotive would be called upon to perform were determined and are summarised as follows :—

1. 700 tons to be hauled at 8 m.p.h. on a straight level track.
2. 700 tons to be hauled at 3 m.p.h. on a 1 in 100 grade.
3. 540 tons to be hauled at 3 m.p.h. on a 1 in 64 grade.
4. 450 tons to be hauled at 3 m.p.h. on a 1 in 40 grade.
5. Locomotive to start 740 tons on a 1 in 100 grade.
6. Locomotive to start 560 tons on a 1 in 64 grade.
7. Locomotive to start 450 tons, 83% of which would be on a 1 in 40 grade.

In order to arrive at the correct size of Diesel locomotive to fulfil the above requirements a detailed survey of the track on the various sections was made and the most severe track gradients were measured at 100-ft intervals and this, together with particulars of the many curves, provided information enabling an estimate of the required horsepower to be made.

In order to keep the horsepower within reasonable limits it was decided that on heavy gradient work a speed of 3 miles per hour would be acceptable and on the Westinghouse Road to Bridgewater Junction run, which has an average gradient of 1 in 89 and includes curves varying from 4½ to 9¾ chains, it was estimated that to move 700 tons at 3 miles per hour would require 400 b.h.p.

It was also calculated that the 400 h.p. selected to fulfil the requirements on the Westinghouse Road to Bridgewater Junction run would also satisfy the requirements under headings (4) and (7) of the specified locomotive performance where a load of 450 tons was required to be hauled up a gradient of 1 in 40 at 3 miles an hour with 83% of the train on the grade.

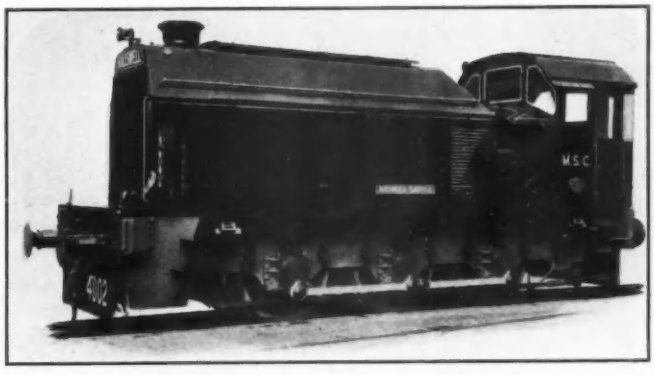
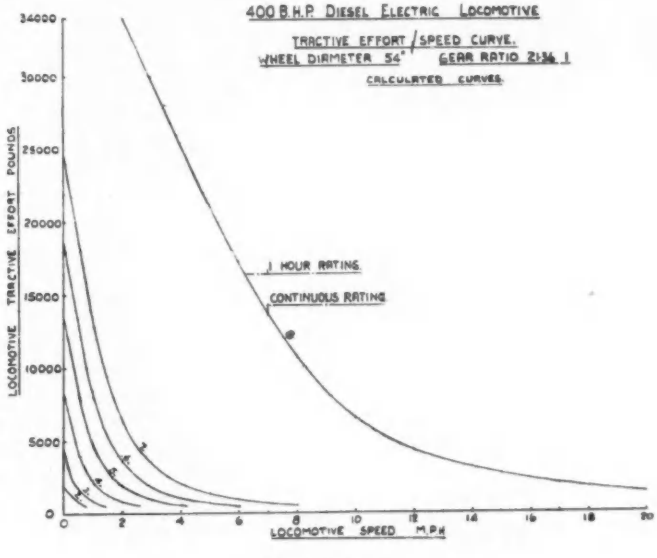


Fig. 1. General view of one of the new locomotives.

Detailed locomotive performance curves were calculated for the specified routes and loads and three of these curves are shown on the accompanying graphs. The full lines show calculated results, the dotted lines show results obtained on the test runs. The tractive effort speed curve is shown on Graph 1.

The current time curves showed that the ratings of the electrical equipment were adequate for the duties involved.



Graph No. 1.

At the same time, many different types of Diesel locomotives were carefully examined. When the investigation had been completed, it was decided that Diesel electric locomotives of 400 b.h.p., having a weight of just over 50 tons, would meet all the various stringent conditions.

The design of the 2 locomotives which are now in service in Manchester was most carefully developed to meet the full requirements of Mr. C. H. Gibson, the Mechanical Engineer of the Canal Company. Everything had to be robust and accessible for easy maintenance and servicing.

Due to the many road crossings that are encountered, very special attention was paid to the design of the cab, fuel tank,

and bonnet, in order to provide the maximum visibility. A complete 'mock-up' of the cab, bonnet and fuel tank was made in wood, and many hours were spent on the drawing board to achieve this visibility.

Fig. 2. View of the cab interior.

From the photograph of the cab interior, (Fig. 2) it will be appreciated that everything has been done for the comfort and convenience of the driver.

The frames and running gear follow orthodox locomotive practice; very strong cross-stays of fabricated steel carry the diesel engine and generator, and also provide support for the nose suspended traction motors. The Buffer Beams are extended to the lowest part of the locomotive, so that in the event of derailment, they afford protection for the traction motor casings. At the same time they are cut away so that Jacks can be easily placed under each corner of the Buffer Beams.

Technical Details of Equipment

Electrical Machines

The electrical machines are of robust construction in order to withstand the heavy mechanical shocks normally experienced in shunting duties. They are built with ease of access for maintenance in mind, and fully conform to BSS.173 (1941) with Class 'B' insulation used throughout.

Main Generator. The main generator is a three field type comprising a self and separate field and a series winding for engine starting. It is a screen protected, single bearing machine solidly coupled through a barring disc to the engine crankshaft, whilst the magnet frame is mounted on the engine bedplate extension. Ventilation is by means of a fan attached to the engine barring disc.

Auxiliary Generator. The auxiliary generator is of the shunt wound, self ventilated, screen protected type and is mounted on slide rails on top of the main generator frame. It is driven from the main generator shaft by vee belts and its output voltage is maintained at a constant 90 volts by means of a carbon pile type regulator.

Traction Motors The traction motors are series wound and force ventilated by means of a separate motor driven blower. They are of the nose suspended type mounted on sleeve bearings on the locomotive axles, the drive to these axles being through double reduction spur gearing which can be de-meshed if it is necessary to tow the locomotive at speeds above its normal maximum.

Blower Motor. The blower motor is a series wound, self ventilated foot mounted machine, the armature being carried in ball bearings.

Control Equipment

The electrical schemes and the control equipments for these locomotives are quite conventional. The two traction motors are connected in permanent parallel across the engine driven main generator; the auxiliary generator supplies current, maintained at a constant voltage by an automatic voltage regulator, for battery charging, auxiliary machines and excitation of the main generator. Engine starting is achieved by motoring the main generator from the battery.

The control cubicle, which is surmounted by an instrument panel (Fig. 3) is fitted against the front wall of the cab and contains all items of control with the exception of the resistance unit which is mounted at the rear of the cab.

The driver's controls comprise controller, reverser, air brake handle and main switch ; the first three, being duplicated on both sides of the cab, are grouped conveniently on the top of the cubicle, whilst standing buttons and deadman pedals are also located for comfortable operation by hand and foot respectively. The controller, reverser and main switch handles are interconnected via a robust mechanical interlock to prevent maloperation.

Dust tight, hinged, lift off doors on all sides and top of the cubicle allow access to all contactors and relays etc; maintenance is further simplified by making all units easily removable from the front.

The driver exercises control over power output by rotating the controller handle, the initial movement of this handle progressively increases the excitation on the main generator by cutting out stages of separate field resistance whilst maintaining the diesel engine speed at minimum. When maximum excitation has been reached this is maintained and further rotation of the controller handle increases the engine speed via a direct mechanical linkage to the governor.

Apart from the mechanical interlock unit linking the operating handles, other safety devices include overspeed and low lubricating oil pressure trips on the engine, a switch to ensure that no power can be applied until sufficient air is available for efficient braking, electrical overload relays to protect the generator, blower relay to ensure that no power can be applied to the

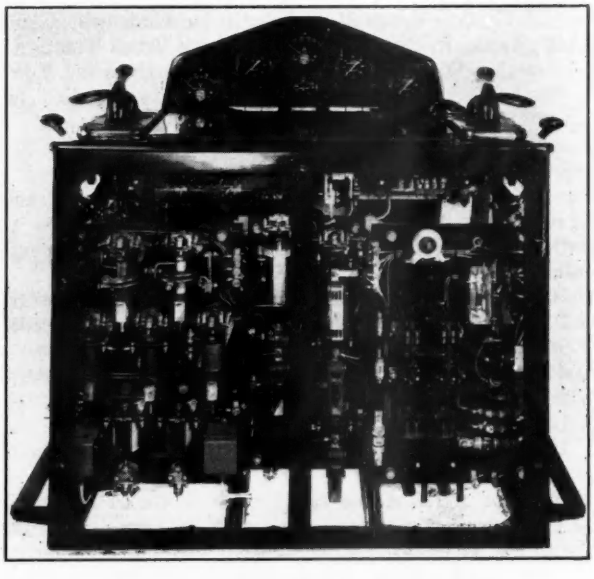


Fig. 3. Instrument panel and control equipment.

traction motors in the event of a failure of the blower and an electrical interlock to ensure that power is removed should the brakes be applied with the controller in an advanced position.

Description of Engine

The engine is a National R4AA6 normally aspirated vertical four stroke model (Fig. 4) having a continuous rating at N.T.P. of 400 B.H.P. at 750 r.p.m. and two hour rating at N.T.P. of 440 B.H.P. at 750 r.p.m. Cylinder dimensions are 9-in bore by 12-in stroke. The cylinder housing is constructed of cast iron and large inspection covers give good access to the main bearings, big end bearings, camshaft, fuel pumps, and push rods. Cylinder liners are of the wet type, i.e. in direct contact with the cooling water. They are made of close grained cast iron chromium hardened and honed internally to finished diameter.

The bedplate is a one piece casting in Meehanite capable of withstanding the buffing shocks imposed during locomotive shunting operations. It incorporates the bottom half of the generator mounting flange and the front power unit support and bolted to the underside is the lubricating oil sump which is fashioned so as to prevent trouble from the surging of the lubricating oil during locomotive movement. The power unit is supported on the locomotive deck by three resilient mountings, one as mentioned before at the forward end of the engine and the other two on the main generator carcase. This form of mounting is considered ideal because no distortion of locomotive deck can be transmitted to the diesel power unit. There is no metallic contact between the power unit and the deck due to rebound springs being fitted and any movement of the power unit is restrained by rubber end stops fitted on the two generator mounting feet.

The engine main bearings are of the loose shell type, white metal lined and are similar for all the journals with the exception of the flywheel end journal, the bearing for which is designed to form a location bearing.

The crankshaft is bolted directly to the armature hub of the main generator. The flywheel end of the bedplate and column housing is rigidly bolted to the engine, the complete close coupled engine generator set being supported as stated on the three point mounting. Each cylinder head is fitted with four valves arranged in pairs, the two inlet valves sharing a common

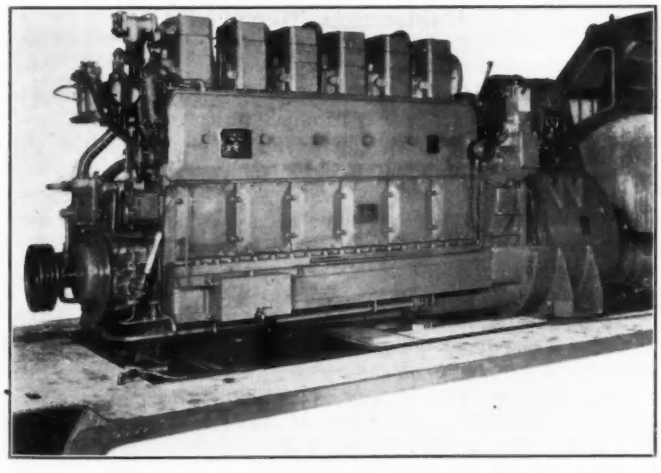
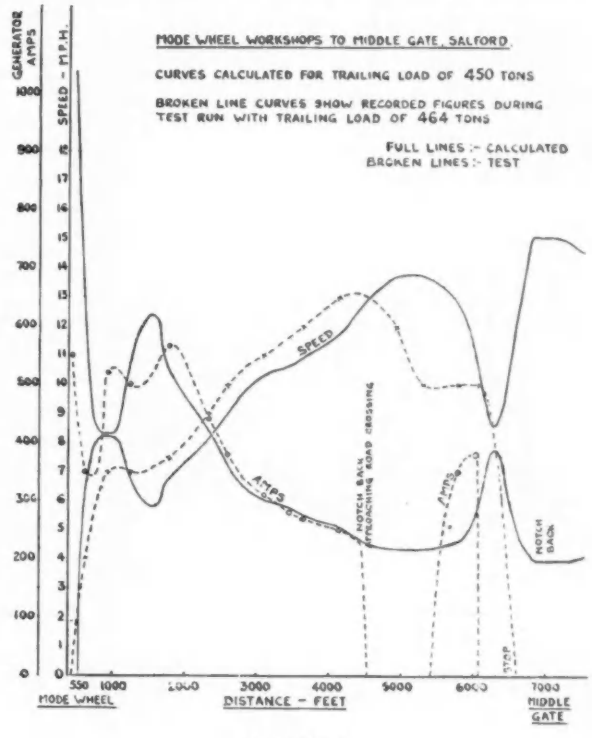


Fig. 4. The traction engine and generators.

passage communicating with the air chamber in the engine column and the two exhaust valves sharing a common exhaust port leading to the exhaust pipe. The valve operating gear is enclosed by the cylinder head covers which are so designed that the atomisers are outside thus preventing any contamination of the lubricating oil and permitting easy removal of the atomisers. The timing wheels are at the flywheel end of the engine and are protected by a cover—no adjustment is necessary. Each pair of valves is operated by a cross beam which is provided with its



Graph No. 2.

own plunger and guide thus relieving the valve spindles of all side thrust. The valve spindles are made of heat resisting steel and double springs are used for each valve The camshaft is fitted with hardened steel cams and is gear driven from the crankshaft. The whole of the valve gear is lubricated by oil under pressure from the main lubricating oil supply.

The pistons are of aluminium alloy, each piston is fitted with four pressure rings and two scraper rings of the slotted type and one of the chamfered type. Small drain holes are drilled in the pistons just below the scraper rings serving to drain off the surplus lubricating oil from the cylinder walls. The gudgeon pins are fully floating and are retained in position by circlips.

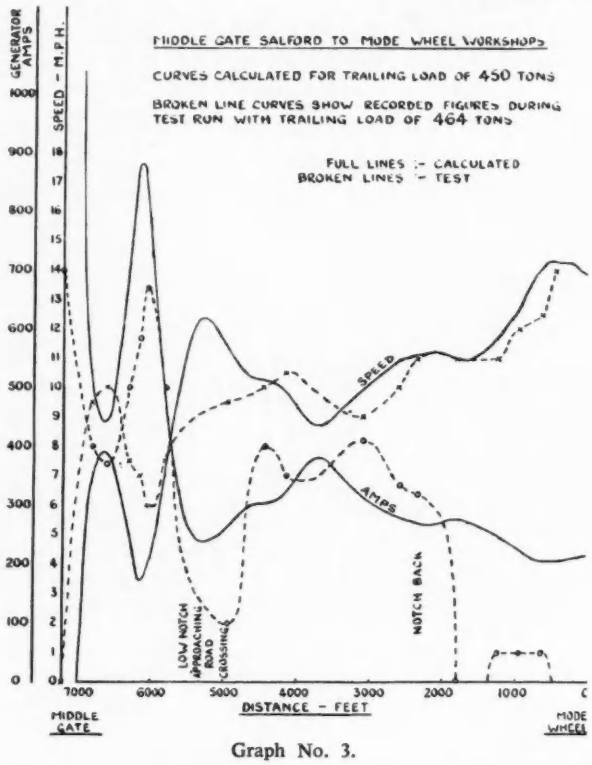
Connecting rods are manufactured of 'H' section stampings of alloy steel drilled the full length of the rod for lubricating the gudgeon pin bearing under pressure. The latter is fitted with a phosphor bronze bush.

A "Woodward" governor is fitted on the engine and is driven through gears from the camshaft gearwheel at the flywheel end of the engine. It is easily removable from the engine so that at overhaul periods any necessary attention may be carried out at the bench.

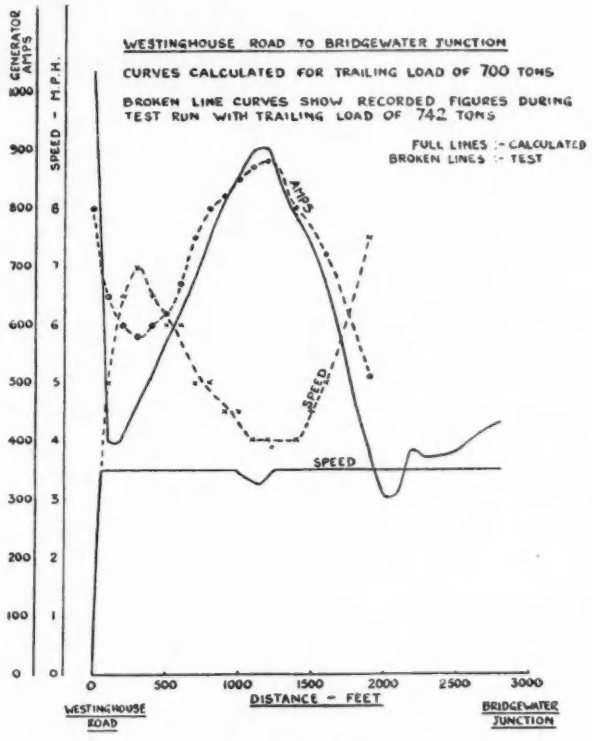
Individual fuel pumps are fitted in their own separate chamber thus ensuring that there is no contamination of the lubricating oil by fuel oil. Fuel oil from the main feed tank is drawn up through a check valve to a rotoplunge gear type fuel oil transfer pump driven from the engine camshaft.

The fuel pressure at the fuel pumps is controlled at approximately 5 lbs. a square inch by means of an orifice plate and excess fuel is returned to the main tank. A filter is fitted in the line before the separate fuel pumps.

Lubricating oil is delivered under pressure to all working parts


MIDDLE GATE SALFORD TO MODE WHEEL WORKSHOPS
CURVES CALCULATED FOR TRAILING LOAD OF 450 TONS
BROKEN LINE CURVES SHOW RECORDED FIGURES DURING TEST RUN WITH TRAILING LOAD OF 464 TONS
FULL LINES :- CALCULATED
BROKEN LINES :- TEST
GENERATOR AMPS
SPEED - M.P.H.
SPEED
AMPS
LOW NOTCH APPROACHING ROAD CROSSING
NOTCH BACK
DISTANCE - FEET
MIDDLE GATE
MODE WHEEL

Graph No. 3.



Graph No. 4.

of the engine by a positive geared pump. Oil is delivered direct from the pump to a filter which embodies three filter cartridges. From the filter the oil is pumped to the radiator and back to the main connection on the column at the free end of the engine. Branches are taken off to all crankshaft main bearings, and the camshaft bearings. Pipes are also led to the governor, gear wheels, lubricating oil pressure failure shutdown gear, overspeed shut down device, pressure gauge etc. Subsidiary mains feed the fuel pump plunger gear and valve gear on the cylinder heads.

Locomotive Acceptance Tests

A 464 ton trailing load was made up for the test run between Mode Wheel Workshops and Middle Gate Salford and return, this being the route which included the New Barns gradient of 1 in 40 (down grade). The recorded test figures during this run agreed very closely with the calculated curves until the driver notched back at the approach to a road crossing. The load was satisfactorily handled down the 1 in 40 gradient and the locomotive was brought to a halt at the bottom with most of the train standing on the incline. (See Graph 2).

Tests carried out on the return journey, i.e. from Middle Gate Salford to Mode Wheel included successful starts on the 1 in 40 gradient, in the first place with 83% of the train on the grade and secondly with 94½% of the train on the grade. On a through run up the grade the minimum speed recorded was 6 m.p.h. All tests at 450 tons were completely satisfactory and for strictly comparable conditions of test load and permitted driving conditions, the results obtained showed a slight margin in hand on speed and generator current. (See Graph 3).

For the second series of tests, a trailing load of 742 tons was available at Weaste for transporting to Bridgewater Junction via Mode Wheel, Middle Gate Salford and Westinghouse Road and although this load was 42 tons in excess of the requirements, the test run was completed satisfactorily, again with a slight margin in hand on speed and generator current. The test figures recorded over the Westinghouse Road to Bridgewater Junction section of track are not strictly comparable with the calculated performance as allowances were made in the calculations for the extremely congested nature of Trafford Park with its numerous road crossings and a speed limit of 3½ m.p.h. was imposed. It was possible however, during the test run to exceed this 3½ m.p.h. and therefor the test load was taken under more normal conditions. From this particular run the specified requirements of 700 tons at 8 m.p.h. on the level and starting 700 tons on 1 in 100 grade were satisfactorily accomplished. (See Graph 4).

Publication Received

Ports of the World (13th Edition). Published by The Shipping World, 1 Arundel Street, London. Price £4.

As in previous editions this volume includes all the chief particulars of accommodation and facilities provided at commercial ports throughout the world and the dues and charges levied. Three new features have been introduced: a summary of development work in hand or projected, an indication of the volume of traffic handled and an approximate distance of the nearest airport or international airport.

Particular attention has been paid in compiling the present edition to specifying what bunkers are obtainable and, in the case of lesser ports, how they are normally shipped. Lists, divided geographically, of the principal bunkering ports are given in the preliminary pages. There is also a table of foreign currencies with their approximate value in terms of the pound Sterling and the U.S. dollar. Another new feature is the section on Communist China, which includes details of charges at Chinese ports.

It has also been possible to extend and revise considerably the information on Polish ports given in previous editions. In other parts of the world about 30 new port entries have been included as well as new introductory sections concerning Suez Canal ports, the St. Lawrence Seaway, South Africa and Spain.

Trade at the Port of Churchill

Abstracts from 18th Annual Report on Hudson Bay Marine Insurance Rates

The Commonwealth Shipping Committee have now published their 18th Report on Hudson Bay Marine Insurance Rates, abstracts of which are given below. The Report is on sale at H.M. Stationery Office, Price 1s.

During the 1958 season of navigation, 55 ships made commercial voyages to Churchill and loaded full cargoes of grain for European destinations. This number of ships was the highest on record, being nine more than in 1957 and seven more than the previous record of 48 ships in the 1956 season. Seventeen ships made two voyages and two ships made three voyages. The 55 ships loaded grain cargoes totalling 19,913,000 bushels for delivery mainly to U.K. and Northern European ports. This total exceeded the previous year's record by 3,336,000 bushels.

Although Churchill dealt with a heavier volume of traffic than in any earlier year, shipping arrivals were spread fairly regularly through the trading season. The first ships entered the port on the 26th July and the last one left on the 11th October. During this period the port was empty of shipping on one day only. The 55 ships occupied the port for a total of 186 days compared with 46 ships and 173 days in 1957. Forty-eight ships were turned round in 4 days or less in 1958 compared with 41 in 1957 and turn-round times for all grain ships averaged 3.38 days (3.75 in 1957). The Report mentions that the turn-round times do not take into account the time ships were held at Churchill Anchorage waiting to berth.

However, the Canadian authorities plan to increase the berthage facilities for ships at Churchill and the additional accommodation should be available in about two years' time. They are also arranging to appoint for the coming season of navigation, a Deputy Port Warden to assist the Port Warden at Churchill. These measures by the Canadian authorities should largely dispel the criticisms concerning the operation of the port which were raised in the 1958 season.

With the exception of the short period in September when the arrival on the 16th of five vessels created congestion, no serious difficulties were encountered at Churchill in 1958. Moreover, the congestion caused by these ships was aggravated by the fact that the s.s. Lord Teedsmuir went aground off the port and suffered damage as a result of which she occupied a berth in Churchill from the 15th to the 24th September before proceeding to Halifax in ballast for permanent repairs. Apart from this one casualty, which does not appear to have been caused by the climatic hazards of the route, no ship using the route was reported as having sustained damage.

Some of the reports received from Masters who voyaged to Churchill in the 1958 season contained suggestions for improving the navigational aids along the route and praise for the assistance received from the coastal radio stations and surface and air patrols. The suggestions have been brought to the notice of the Canadian authorities who closely study the navigational facilities of the route and introduce improvements where circumstances permit. In 1958, the Canadian Government replaced the former light structures at Nottingham Island, Mansel Island and Charles Island (East End) by new steel towers equipped with radar reflectors. They increased the intensity of all unwatched lights in Hudson Strait to the maximum possible for the type of light and established automatic radio beacons at Churchill and Chesterfield Inlet.

As in the past, the Canadian Government ice-breaker N. B. McLean was stationed in the area throughout the trading season and was available to give Masters information and advice. Aerial surveys of the route were again arranged, the first of which was made before the opening of the navigation season. Twelve aerial surveys were made extending between the 18th July and the 27th August. The area covered included the Hudson Bay and Strait, together with the additional areas of Frobisher Bay and Ungava Bay. Churchill was used as the permanent operating base with Coral Harbour and Frobisher Bay as secondaries.

The second aerial survey was made on 22nd July and planned to meet the first vessels for Churchill at the Eastern entrance to Hudson Strait. Contact by radio was maintained between the aeroplane and the Canadian Government ice-breaker Labrador which escorted the first vessel through the Strait to Digges Island and also gave advice as to the route to be followed to the following ships. The Masters of the first ships to arrive at Churchill reported that the route was free from ice fields and, apart from patches of drift ice and fog, no navigational difficulties were experienced either on the inward or outward passages through Hudson Bay and Strait.

Reports on ice weather conditions made by the Coast Stations along the route were collated with the survey reports made by the aerial patrol and were made available to shipping on request. The reports were also sent to London where they were forwarded to the Shipping Press for publication. The Canadian authorities plan to operate similar aerial ice patrols during the 1959 season of navigation. The patrols will start on the 1st July and will continue for as long as the survey is deemed necessary. The survey will be preceded by two preliminary flights, the first in the third week in May and the second in the third week in June.

At the end of the 1958 season the quantity of grain in store at Churchill was 2,266,000 bushels. The stocks have been built up during the winter months to provide a total store of 4,870,000 bushels when the 1959 season opens.

In accordance with usual practice, the Report draws the attention of Underwriters to the facts contained therein in order that they may be taken into account when the position is reviewed for the forthcoming season. Referring to two resolutions passed by the Hudson Bay Route Association at their annual convention the previous year, seeking reductions in the Hudson Bay Scale of Additional Premiums, the Report states that these resolutions were again brought to the notice of the Underwriters.

A note by the chairman, Sir Clement Jones, refers to a letter from the Department of Transport, Ottawa, respecting radio communication between ships in Hudson Strait and icebreakers and aircraft. The letter stated that some ships did not acknowledge radio calls with the result that aircraft were unable to pass messages about ice. It is suggested that if ships cannot maintain continuous radio watch an extension to the radio telephone line from the radio room to the bridge might be the solution.

Development of Chinese Ports

The British Council for the Promotion of International Trade recently published a brief list of the measures being undertaken in China to improve port facilities and so achieve a quicker turn-round of shipping. The Port of Dairen is being supplied with further cargo handling equipment and at Chinwangtao work is in progress on the second stage of a major extension of the wharves which will provide fully equipped berthing space for 2 ships of up to 15,000 tons. At Tientsin work is nearing completion to provide berths for 5 ocean-going ships together with mechanical loading and unloading facilities. The pier at the Whampoa outer harbour at the Port of Canton is being extended to a length of some 2,700-ft. and two further piers for passenger traffic are being completed in the inner harbour. Improvements are also in hand at the ports of Chinsien, Chankiang, Swatow and Kongmoon.

Work is in progress at the Port of Wuhan on the Yangtse River where ten new fully-equipped wharves are planned to handle coal, ore, steel and grain cargoes. A branch railway line from these wharves will link them directly with the main line between Peking and Canton.

Improvements at King George Dock, Hull

The British Transport Commission have authorised further improvements at King George Dock, Hull. The scheme, which is estimated to cost £4,750,000 includes the extension of three quays and the provision of additional transit sheds, cranes, grain elevators and silo accommodation.

King George Dock, the largest of the 11 docks in the Port of Hull owned and managed by the Commission, was built jointly by the former North Eastern and Hull and Barnsley Railway Companies and was opened in 1914. It has a water area of 53 acres, and access for vessels from the River Humber is by an entrance lock 750-ft. in length and 85-ft. in width, containing three sets of gates that divide the lock into two compartments of 500-ft. and 250-ft. Vessels drawing up to approximately 27-ft. are able to enter or leave on any tide.

The principal quays are as follows:

Quay	Location	Length ft.
No. 1	North-west Arm, north side	1,270
No. 3	North-west Arm, south side	1,350
No. 8	South side	951
No. 12	North-east Arm, south side	1,356
		4,927

Six transit sheds, each 377-ft. in length, provide covered accommodation: three are single-storey structures 87½-ft. wide and three double-storey buildings 67½-ft. wide. These sheds, constructed when the dock was built, are situated on Quays Nos. 1 and 3 on the north and south sides respectively of the north-west arm of the dock. At the western end of this arm is a grain silo with a capacity of 40,000 tons, the bulk grain being discharged by pneumatic or bucket elevators from vessels berthed at the adjoining quays and carried to the silo by underground belt conveyors.

On the north side of the dock are two electric and two hydraulic coal hoists. For some years past coal exports have drastically declined and because of this and the availability of adequate coal loading capacity at other docks at the port it has been decided to eliminate the facilities in King George Dock.

The eastern end of the dock is equipped with two graving docks for the examination and repair of vessels: No. 1 has a length of 417-ft. and an entrance 66-ft. in width, and No. 2 is 520-ft. long with a 72-ft. entrance. In addition, Quay No. 11, 275-ft. in length, which is at the western end of, and at right angles to, No. 12 Quay, is used for vessels undergoing repairs afloat.

King George Dock is the centre of a world-wide trade, and the principal areas from and to which goods are imported and exported are North and South America, Australia, New Zealand, India and the Far East, and South and West Africa. The most important inwards traffics are grain and flour; oil seeds and nuts; food, provisions, fruit and vegetables; wool; pitwood and other timber; and ores. Exported commodities include iron and steel goods; vehicles and parts; chemicals; and miscellaneous cargo.

Within recent years, the Commission have spent over £1½ million on improvements at King George Dock. Foremost amongst these was the complete replacement of the quay cranes by modern units with a lifting capacity of 6 tons and an outreach of 70-ft.; the reconstruction in concrete of No. 12 Quay, originally a timber structure; the renewal of the railway lines on other quays and the laying of new surfaces flush in concrete; and the modernisation of the electrical distribution system. To improve the rate of discharge of grain, bucket grain elevators, formerly in operation at Quay No. 1, were replaced by four shore-based pneumatic suction units, each with a capacity of 120 tons an hour. In addition, the Commission have on hire from the Ministry of Transport two floating elevators which have proved valuable in the overside discharge of grain from ocean vessels to barges moored alongside.

For some time past, shipowners, importers and exporters have made representations about the facilities at King George Dock and the suggestions made have included extra quayage adequate to accommodate vessels of the length and number which trade, or might trade, to the port; more covered accommodation on the quays; improved grain discharging facilities and enlargement of the silo; the provision of a berth specially equipped for the unloading of bulk dry cargoes such as chemicals and ores; and better facilities for the repair of vessels afloat. The Commission therefore made a close study of the present facilities and, taking into account the various representations made, have now decided upon the following major scheme of improvement.

North Quay

The north side of the dock is 3,700-ft. long, of which 1,270-ft. is occupied by Quay No. 1, used for the discharge of grain and the loading and unloading of general cargo. The remaining 2,430-ft. has hitherto been employed mainly in the berthing of vessels loading coal, but it is now proposed to remove the coal loading appliances and to convert the present echelon formation into a straight quay in continuation of Quay No. 1. On the redeveloped section would be provided four new single-storey transit sheds, two 450-ft. in length and 120-ft. in width and two 500-ft. in length and 150-ft. in width, the distance from the cope to the front of the sheds being about 60-ft. In this width would be laid a crane track of 15-ft. gauge and three railway lines, the whole surface being finished flush in concrete. The rear of the sheds would be served by railway lines running alongside and access for road vehicles would be provided by an extension of the existing 30-ft. road.

The scheme would result in a straight quay 3,700-ft. in length, capable of providing simultaneous berthing for six of the largest ships using the dock. It would be equipped with seven transit sheds with a total floor area of 357,000 sq. ft., and because of the better use that could be made of cranage on a continuous quay, only ten 6/3-ton units of 70-ft. radius would be required in addition to the 11 now installed.

No. 12 Quay

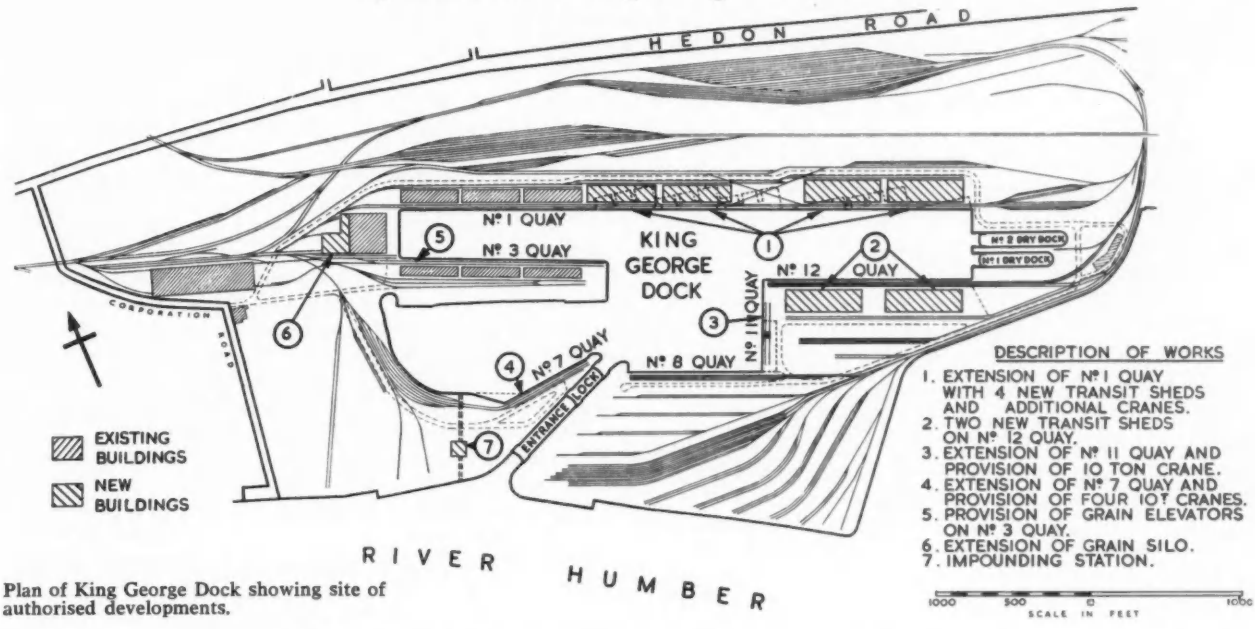
It is proposed to complete the modernisation of this quay by constructing on it two single-storey transit sheds each 500-ft. in length and 150-ft. in width with rail and road access. Two railway lines would be provided in front of the shed and two at the rear and they would be set flush in concrete so as to facilitate the movement of road vehicles to and from the sheds.

No. 11 Quay

No. 11 Quay is a timber structure provided in 1914 and is in a bad condition. It is proposed to reconstruct it in concrete, to lengthen it from 275 to 600-ft. and to equip it with a 10-ton electric portal crane. These works will provide much improved facilities for the ship repairing trade.

No. 7 Quay

The south western section has not been developed but when the dock was originally constructed a quay 450-ft. in length and known as No. 7 was provided. It has hitherto been used only by vessels lying up but it is now proposed that it should be extended to 600-ft. and equipped with four 10-ton electric cranes for the discharging of bulk dry cargoes by grab. Four railway lines would be laid on the quay and nearby there would be sidings for 200 wagons. The water area adjacent to the quay would be


HEDON ROAD
Nº 1 QUAY
Nº 3 QUAY
KING GEORGE DOCK
Nº 12 QUAY
Nº 11 QUAY
Nº 8 QUAY
Nº 7 QUAY
ENTRANCE LOCK
CORPORATION ROAD
EXISTING BUILDINGS
NEW BUILDINGS
RIVER HUMBER
DESCRIPTION OF WORKS
1. EXTENSION OF Nº 1 QUAY WITH 4 NEW TRANSIT SHEDS AND ADDITIONAL CRANES.
2. TWO NEW TRANSIT SHEDS ON Nº 12 QUAY.
3. EXTENSION OF Nº 11 QUAY AND PROVISION OF 10 TON CRANE.
4. EXTENSION OF Nº 7 QUAY AND PROVISION OF FOUR 10T CRANES.
5. PROVISION OF GRAIN ELEVATORS ON Nº 3 QUAY.
6. EXTENSION OF GRAIN SILO.
7. IMPOUNDING STATION.
SCALE IN FEET

Plan of King George Dock showing site of authorised developments.

dredged to a sufficient depth to allow vessels to approach and lie alongside.

Provision of Grain Elevators and Extension of Silo

It is proposed to scrap the four-bucket elevators on No. 3 Quay and to provide two pneumatic elevators similar to those on the North Quay. The track on which the elevators would operate would be extended to the westward so that the machines could be moved clear of the quay when the berth was occupied by a vessel discharging or loading general goods. It is also proposed to provide a floating elevator with a capacity of 200 tons per hour and similar in design to those on hire from the Ministry of Transport. The silo has 288 bins and it is proposed that a further 144 bins should be provided, thus increasing the storage capacity by 50 per cent to 60,000 tons.

Entry of Larger Vessels

Although King George Dock is capable of receiving and accommodating on all tides vessels drawing up to about 27-ft., it is realised there are some ships in the ocean cargo trades which, because of their greater draft, do not have free access. The Commission have therefore appointed a team of scientists and engineers to study the hydrographic conditions around the dock entrance and, when the results of this study and of other investigations are complete, it is hoped to introduce measures that would enable larger vessels than at present to enter or leave the dock on all tides. These measures may take the form of the installation of impounding pumps (with associated culverts) to transfer water from the river into the dock and so raise the minimum level on the inner sill by about 4-ft.

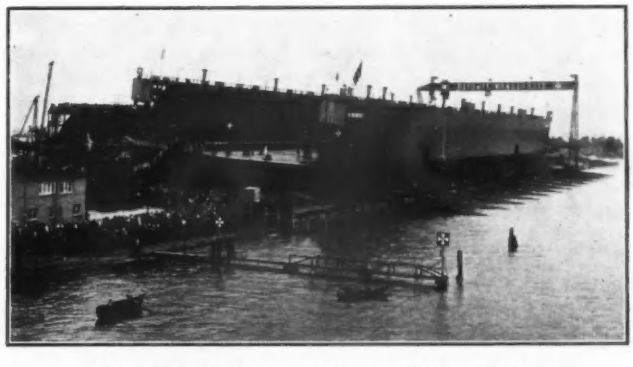
Mechanisation of Transit Shed Operations

An essential feature of the economic operation of a modern port is the highest possible degree of mechanisation of transit shed operations. The scheme therefore includes a sum of £150,000 for a modern fleet of mobile cranes, fork-lift trucks and other mechanical aids.

A Large German Floating Dock

"Deutsche Werft Dock 5," a floating dock built by Gutehoffnungshütte Sterkrade A.G. for the firm of Deutsche Werft A.G., Hamburg, is one of the largest docks of its kind in the world. It was launched in October 1958 at the Gutehoffnungshütte construction yard at Blexen on the River Weser and towed to its destination.

The new dock, which is of all-welded construction, has a lifting capacity of 30,000 tons and is designed to handle vessels of up to 65,000 tons deadweight. It has an overall length of 226 m., a length of 210 m. over keel blocks, an overall width of 47 m., a clear width of 38 m., and a draught of 16.7 m. when flooded. The pontoon is divided by means of three longitudinal and five transverse bulkheads into 24 ballast tanks capable of being flooded and emptied individually. These operations are guided from a central control room provided with indicators and other equipment for checking and regulating the trim of the dock, the amounts of water entering or leaving the tanks, etc. Six specially designed vertical spindle pumps are installed, the operation of pumping out the tanks being accomplished in 135 minutes.



Launching Ceremony of the new floating dock.

The dock is equipped with piping systems for the distribution of steam, water, compressed air, gas and oxygen (for welding), foam (for fire-fighting purposes), etc., together with ventilation and heating systems. Mounted on the side walls are two 15-ton electric portal type travelling cranes.

Oil Tanker Accommodation at Tranmere

New Terminal Under Construction

(Specially Contributed)

A major oil terminal for handling 65,000 d.w. ton supertankers is being developed jointly by the Mersey Docks and Harbour Board and Shell Refining Company Limited at Tranmere, on the Cheshire side of the River Mersey.

The planning and development of this project has from the outset presented many unusual and complicated engineering problems, not the least being that posed by the 30-ft. tidal range which, together with a 30-ft. pumping differential on the tankers, would have involved a vertical movement of up to 60-ft. between a fixed quay and the ship moored alongside.

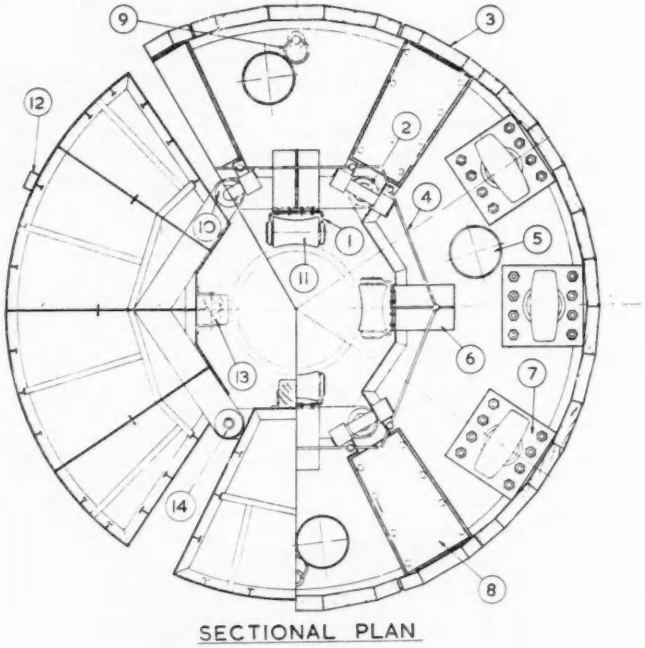
The Tranmere scheme, for which Parliamentary powers were obtained, was developed after an examination by the Shell Refining Company in Collaboration with their Dutch associates, Shell Tankers Limited and the Mersey Docks and Harbour Board, and incorporates two floating stages with road and pipeline access from a forked approach jetty, and twelve floating Dolphins. These Dolphins incorporate some new and ingenious features for which patent applications are pending. The idea for the use of these Dolphins was initiated by the Engineers of the Shell Refinery Company, but the final form of the design is the result of close collaboration with the Mersey Docks and Harbour Board and the Consulting Engineers, Messrs. Posford, Pavry and Partners, acting for the Cleveland Bridge and Engineering Co. Ltd. These twelve Dolphins with the two 366-ft. long floating stages combine to give a considerable saving in construction costs compared with the single 2,000-ft. long floating stage originally envisaged.

Each floating stage is designed to act as a gravity fender capable of absorbing the energy of a fully loaded supertanker, berthing at an assumed speed of 9-ins. a second, at each end of the stage: this is equivalent to a kinetic energy absorption of about 460-ft./tons. Four heavy Mannesmann tubes are placed in the river bed in pairs behind the ends of each stage, the connections between stage and tube are 150-ft. long lattice steel booms attached suitably on the stage to allow for vertical tidal movement and fixed to the Mannesmann tubes through a linkage carrying a counterbalance weight of 100-tons. This counterbalance provides a progressive increase in resistance to backward movement of the stage.

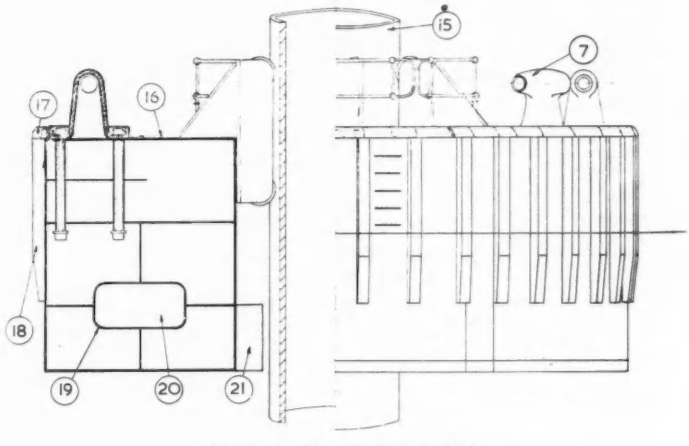
Besides carrying road and footways the approach jetty carries pipelines varying in diameter from 16-ins. to 30-ins. together with light, power and telephone cables. The 30-ins. dia. crude oil pipes are brought at a fixed level to the hose-handling gantries built over the floating stages, an arrangement which eliminates all flexible pipe joints except those at the gantries.

Crude oil is pumped to balance tanks on shore, utilising the ships pumps, and from there by shore pumps to Stanlow Refinery nine miles away. Simultaneuos discharge of two 65,000 d.w.t. tankers will be possible, giving a total daily discharge of 150,000-tons of oil.

The major dredging in unbroken sandstone for the berths and approaches was carried out by the Westminster Dredging Co. Ltd. of London and Bromborough. The main contractors for the approach jetty and stages are Peter Lind and Co. Ltd., the Cleveland Bridge and Engineering Co. Ltd. being the Sub-contractors for the whole of the floating structures and booms including the Dolphin ring pontoons in the design of which they were assisted by Posford, Pavry and Partners.



SECTIONAL PLAN



SECTIONAL ELEVATION

NOTES

1. Roller fitting 1-in. thick bent 3-ft. 6-in. by 6-ft. 1-in., drilled to suit 7-in. diameter pin through rollers; ½-in. thick stiffeners shaped, fitted and welded in.
2. 9 No. ¾-in. plate bent and welded to deck plates and angle frame with 6-in. x 3-in. channel by 2-ft. 10-in. bolted to one strap only by one bolt.
3. ¾-in. thick plate bent and shaped to fit and bolted to cope timbers. Holes in timber oversize to allow free movement.
4. Heavy industrial type handrails and standards.
5. Manhole with access ladder to inside of segment; 1-in. by ⅜-in. ring for retaining deck finish.
6. ¾-in. thick vertical stiffener with two 12-in. x ⅞-in. flange plates welded on and welded to deck plate and roller brackets.
7. Bollards bolted to deck with eight 3-in. galvanised bolts.
8. ¾-in. thick plate with ⅜-in. x ⅜-in. edge plate welded on to suit deck finish. Material bolted to deck on one side only to allow free movement.
9. Mooring rings to take a pull of 10 tons.
10. 6-in. diameter mild steel fixing pin with solid ends.
11. Laminated nylon rollers.
12. ¾-in. diameter steel rod step irons at 9-in. centres.
13. 9-in. by 4-in. by ¾-in. angles by 3-ft. long welded on and drilled for timber.
14. 16-in. by 1-in. plates at top and bottom with ½-in. thick boss welded on at pin connection.
15. Mannesmann tube.
16. Deck finish.
17. 8-in. by 6-in. pitch pine horizontal cope timbers.
18. 6-in. by 6-in. pitch pine fendering.
19. 6-in. by ½-in. thick compensating edge plate welded to main diaphragm.
20. Access opening in diaphragm.
21. 4 greenheart guide timbers.

Oil Tanker Accommodation at Tranmere—continued

Technical Description of the Mooring Dolphins

The design requirements for the Dolphins specified by the Mersey Docks and Harbour Board were that they should have a freeboard of 4-ft. and be suitable for encircling a Mannesmann tube 5-ft. 5-in. outside diameter; they should be capable of withstanding a pull 50% in excess of the expected maximum mooring pull of 100-tons applied at 20° to the horizontal. Six mooring bollards had to be provided on each Dolphin in two groups of three 180° apart, each group being so arranged that three ropes can be run to approximately the same position on the Dolphin. Each rope will be controlled with a compensating device to give a constant pre-tension of 35-tons. Timber fendering had to be provided all round each Dolphin to make them suitable for a motor launch to appproach and tie up.

In the design adopted the Dolphin pontoon is formed of four segments, two large segments carrying the mooring bollards and two small segments acting as spacing sections. Under full load on an ebbing tide the direct vertical component is 33-tons and the dead weight of the Dolphin pontoon must be greater than this force plus a suitable allowance for the sliding friction against the Mannesmann tube.

Due to the very wide tidal range and the almost continuous movement against the Mannesmann steel tube, special consideration had to be given to the means of achieving movement under all weather conditions with the minimum of maintenance. Sliding surfaces of timber, metal or plastic rubbing plates were considered unsuitable due to the high frictional resistance that can be developed. Rollers were considered essential to bring the friction within acceptable limits, but as these are moveable parts, corrosion and subsequent seizing up was a possibility. The use of reinforced laminated nylon for these rollers was investigated, and it was found this material had a crushing strength considerably in excess of the line loads required and was unaffected by sea water; further, that if the oil impregnated type of plastic was used, greasing or oiling would not be essential, but provision for greasing was incorporated within the rollers as a precaution.

The plan and typical cross-section shown in the illustration illustrates the main features of the design adopted.

The four segments are fabricated from welded steel plates and connected by specially formed 6-in. diameter pins passing through connection plates protruding from the top and bottom plates of each segment. No underwater fastening is necessary as the pins are fed into the plates from above, and to facilitate the location the end of the pin is tapered. The pin is locked into position by fastening a horizontal member across the head into slots already prepared on each segment joined.

The high freeboard required makes the floating stability of each individual section uneconomic in ballasting and draught, but when connected into a ring or horseshoe form the four segments have sufficient inertia at the water plane area for all maintenance purposes.

The mooring pull is transferred through the bollards to vertical diaphragms which also incorporate anchorage pockets for the holding down bolts. These diaphragms in turn form the main stiffeners to the outside plates of the segment.

The dead weight of the completed Dolphin ring pontoon when fully ballasted is 70 tons which gives an approximate weight of 35-tons to overcome the friction imposed by the pull of 100-tons at 20° to horizontal plus a small flotation in this position.

The rollers are sited to give the line of the resultant pull applied at 20° angle from the head of the bollard, such that it passes within the space between the upper and lower rollers, also that the upper roller is above the line of pull when horizontal. By this arrangement no roller is continuously immersed in the sea.

To prevent the Dolphin pontoon from being "hung-up" on the top of the Mannesmann tube in the event of an override of the top roller due to an exceptionally high tide greenheart guide timbers are provided at the bottom of the segments with sufficient clearance to prevent rubbing on the Mannesmann tube under normal usage.

The upper surface of the top plate of the segment is given a carborundum non-slip treatment, and the space between the segments is covered with a junction plate to enable free access round the Dolphin to the Seaward Side; handrails are provided on the inner side as a protection against falling into the inner well and are so sited as to assist men hauling on the ropes.

Launch mooring rings are provided on each segment and these can also be used for a three point lift should any segment require to be lifted out of the water by crane for maintenance.

Access manholes are provided in each segment of the Dolphin pontoons.

The shape of the segments is such that the angular movement between each segment when fastened by the locating pins is sufficient to give clearance to the Mannesmann tube when one locating pin is removed, thus the four segments of the Dolphin can be floated round the Mannesmann by suitable ballasting and then brought together and connected.

Correspondence

To the Editor of "The Dock and Harbour Authority."

Sir,—

Administration of Terminal Facilities for Overseas Trade

The two articles by Mr. P. A. T. Chrimes contain sufficient constructive thinking to alter radically the accepted methods of passing goods through a port. Out of the wealth of ideas may I select that which deals with the scope of the Port Authority. With the statement (in para. 9) "the port authority should have ownership of and control over the physical assets represented by wharves and landing places" there can be no dissent. That "the provision of services required for the working of those basic facilities should, generally speaking, be left to those who need to use them" is far from being generally accepted.

For many decades the school of thought that would limit the functions of a port authority to those of a landlord, prevailed. The consequences of the changes in cargo handling methods since 1945 have caused many people to consider that the port authority should now take a more active part. Mechanisation is of restricted benefit to a port if its manifestations are sporadic and intermittent. The value of mechanised berths increases enormously as soon as the number is such that an incoming vessel can rely on being allotted one. The cost of the equipment restricts its use however, to port authorities and "substantial contractors" (para. 44). To mechanise a port fully—that is, to the limit at present reached and found to be practicable—demands a carefully phased programme and one in which there is a flexibility that will profit from the necessarily empirical nature of the process.

This process, as has only too painfully been learnt, does not stop at machines. It has included sheds, warehouses and piling grounds. To secure the full benefits of mechanisation new types of port accommodation have been constructed at very considerable expense. Ports and their buildings are the most rigid link in the chain of transportation. They cannot be altered as easily as can the design of ships, or the ordering of cargo handling machinery.

Problems that require solution with the national Customs, the fabric insurance authorities, as well as the ever present matter of

accident prevention, have followed closely in the wake of mechanisation. The matters I have mentioned are all of the type that are now being solved by forward-looking port authorities. Mr. Chrimes does suggest the formation of a stevedoring company, subsidiary to the port authority and acting as one of the contractors in the port. This is the same leopard but with a different set of spots, for there are already port authorities who either do the whole or part of the physical operations on the cargo that passes through the ports they control.

A port authority which is directly responsible for the stevedoring work (and the term will include work on the quay, transit sheds and warehouses) has, through personal experience, acquired a close and direct understanding of the requirements of mechanisation. It is therefore in a better position to re-construct its port on modern lines than the port authority that has to assimilate and reconcile the conflicting views of several operators; none of these may have had the capital to experiment on the scale enjoyed by the port authority.

In the few ports where the port authority takes a direct hand in daily operations the progress made in the mechanical handling of cargo would seem to support the argument.

Yours faithfully,

Cranleigh, Surrey.
12th November 1959.

R. B. ORAM,
Port Consultant.

Curing Concrete

Important Feature in Strength Development*

By C. S. FORUM

General

Although curing is the final phase in the production of concrete, it is by no means the least important. It involves keeping the concrete moist and, if necessary, protecting it from excessive loss or gain in heat, and most of the desirable properties of concrete are improved as the duration and effectiveness of the curing are increased. This applies not only to strength, but also to durability, impermeability and resistance to wear, chemical attack and weathering. Ineffective curing is all too often the cause of such defects as crazing, cracking, insufficient strength development and low durability, even in well designed concretes, and it is regrettable that curing is so often considered of secondary importance and is therefore neglected.

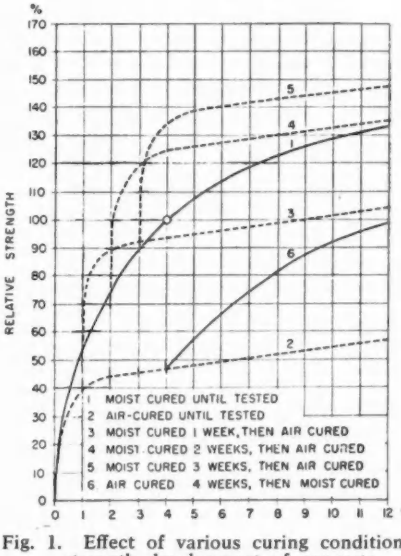
The properties of a given concrete are mainly dependent on the properties of the cement-water-paste and thus on the reactions which take place between the dissolved constituents of the cement particles and water—the so-called hydration of the cement. If sufficient water is available this process continues until the supply of cement is exhausted. The time required for complete hydration of cement in a concrete mix depends upon several factors, such as type of cement, cement content of mix, ambient temperature and degree of saturation of paste. Under ordinary circumstances the hydration processes may continue for several years, although the rate of hydration decreases rapidly after the first month or so.

The amount of water necessary for reasonably complete hydration is about 20-30% of the weight of the cement, which is only about half the amount contained in an average mix. However, maximum rate of hydration at a given temperature is only obtained when the processes take place in the presence of surplus water. Moreover, the chemical processes in the cement paste remove free water from the pores — so-called self-desiccation—and the amount of water needed to replenish this loss during the first week is about 2 litres per sack of cement for average mixes. Tests indicate that if evaporation is prevented but no water is added to replenish that removed by self-desiccation, the effect will be to arrest hydration in concretes with w/c ratios lower than 0.4 and to retard the process in concretes with higher w/c ratios.

Fig. 1 illustrates the effect of various curing conditions on the strength development of concrete. The gain in strength through prolonged moist curing and the high rate of strength development at early ages are evident and emphasise the necessity of applying moist curing at as early a stage as possible. The figure also shows that loss of strength due to delayed or interrupted moist curing may be at least partially regained if curing is resumed at a later stage. In practice, however, it is extremely difficult to resaturate concrete masses, and concrete which is sheltered from rain—for example indoor concrete—will have no opportunity of absorbing moisture at later ages. A permanent loss in strength may therefore occur unless continuous moist curing is applied from the earliest possible moment.

The curing temperature has a marked effect on the strength development of concrete, as illustrated in Fig. 2. Low curing temperatures lead to decreased rate of strength development and extended moist curing is required under such conditions in order to develop a given strength. High curing temperatures lead to accelerated strength development, but also to modifications in the hydration products which may lead to lower ultimate strengths.

Finally, it is stressed that effective moist curing is essential in order to eliminate differential shrinkage and consequent crazing and cracking. If a concrete member is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RELATIVE STRENGTH
1 MOIST CURED UNTIL TESTED
2 AIR-CURED UNTIL TESTED
3 MOIST CURED 1 WEEK, THEN AIR CURED
4 MOIST CURED 2 WEEKS, THEN AIR CURED
5 MOIST CURED 3 WEEKS, THEN AIR CURED
6 AIR CURED 4 WEEKS, THEN MOIST CURED
WEEKS

Fig. 1. Effect of various curing conditions on strength development of concrete.

[From "Betonbogen" by Meyer, Forum and Krenchel. Courtesy Technical Information Office of Danish Cement Works.]

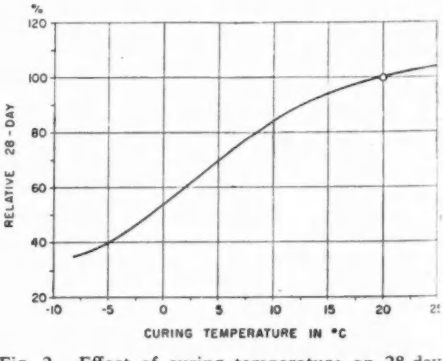


Fig. 2. Effect of curing temperature on 28-day strength of concrete cured at approximately 2°C for the first 3 days.

[From "Betonbogen" by Meyer, Forum and Krenchel. Courtesy Technical Information Office of Danish Cement Works.]

*Reproduced by arrangement with "C. N. Post," February 1959.

not moist cured, the surfaces will dry out and shrink while the main body remains moist and constant in volume. The result will be internal stresses which will create tension in the outer layer, and cracks may form, particularly if strength development in this layer has been retarded due to lack of moisture.

Curing at ordinary temperatures

From what has been stated above it is apparent that the aim of field curing at ordinary temperatures should be to prevent and/or compensate the loss of necessary moisture for a period of time and thus enable the concrete to develop its potential properties. It is also apparent that curing should commence at the earliest possible stage and that the longer the period of curing. the better will be the quality of the concrete.

In practice it is necessary to balance quality requirements with those of economy, and the minimum period of moist curing is generally specified as 7 days for standard Portland cement. Better practice would call for 10 days, and where special requirements are made for the concrete, the period should be extended. Watertight concrete should, for example, be moist cured for at least 14 days. Rapid-hardening cements require shorter periods of moist curing (about half), and slow-hardening (e.g. pozzolanic cements) longer periods than standard cement.

Too rapid drying of exposed concrete surfaces may result in serious surface cracking and crazing and if there is, for any reason, a delay in applying moist curing, it is recommended that the fresh concrete be protected from sun and wind until adequate curing is commenced. Furthermore, it should be remembered that corners and edges of members become dry more readily than other parts and special attention must be given to them.

The following methods of curing are acceptable:

1. Covering with wet burlap or cotton mats

This is an excellent method of moist curing concrete, as the burlap not only holds the moisture needed for good moist curing but also shades concrete exposed to the sun and shelters it from wind, whereby periods of drying are less likely to occur. The burlap or cotton mats should be in direct contact with the concrete surface and should be kept continuously wet, for example by means of perforated canvas hose laid on top. When proper care is taken burlap or mats may be laid, without damage to the surface, as soon as the concrete has taken its initial set. The method is mostly used for large unformed surfaces but is also useful on formed surfaces provided the burlap is kept in contact with the surface of the concrete.

2. Covering with moist sand, sawdust, straw, etc.

An approximately 2-in. thick layer of sand or sawdust or a 6-in. layer of straw is spread over the surface and kept moist by frequent wetting. The materials used and the manner of placing them must be so chosen that staining, marking or contamination of the surface is avoided. (Wet sawdust is liable to leave stains which are extremely difficult to remove). Curing by these methods, which should, of course, be restricted to horizontal surfaces, should not be commenced until concrete has attained its final set and is strong enough to resist damage.

3. Covering with waterproof paper.

The paper should be held close against the concrete surface and seams between adjacent sheets should be tightly sealed. The concrete surface beneath the paper should be inspected occasionally and rewetted if found dry, the openings then being resealed. This method is best suited for flat work such as roads, pavings and floors, and if care is excercised the paper can be laid shortly after the concrete has taken its initial set.

Plastic sheets have been used instead of paper as they provide an effective moisture barrier and can be used several times. However, clear plastic sheeting should not be used on surfaces exposed to direct sunlight owing to the heat absorption.

4. Spraying

Spraying should be continuous or, if intermittent, should be repeated at frequent intervals to prevent local drying. The concrete surface cannot be sprayed until it has attained sufficient strength to resist damage and washing out of cement.

5. Ponding

This method consists of building small earth dykes around the circumference of the exposed surfaces and flooding the concrete within the dykes. The method may be aplied after the same time interval as for spraying, and on horizontal surfaces only.

6. Retaining forms in place

This method is applicable to beams, columns and similar members, where the forms cover a considerable part of the surface area. It is not applicable to floors, pavings, roads, etc. Wooden forms provide thermal insulation and both wooden and metal forms provide satisfactory protection against evaporation provided that the exposed top surfaces of the concrete are kept wet in such a manner that water will find its way down between the concrete and the form, and that wooden forms are sprayed at frequent intervals to prevent their drying out. If these conditions cannot be fulfilled forms should be removed as quickly as possible (with due regard to structural requirements) so that effective moist curing may be commenced with as little delay as possible after placing. Exceptions are the surfaces of ceilings and walls inside buildings, which generally receive no other curing than effected by leaving the forms in place for from 4 to 7 days. This practise is usually accepted in such cases because of the difficulties involved and the inconvenience to workers when moist curing is effected, but there is no doubt that it leads to lower quality concrete than would be the case if sufficient moisture were made available.

7. Backfill

There is no better curing and protection than that provided by well moistened backfill.

8. Perforated canvas hose

Steeply sloped or vertical surfaces may be kept completely and continuously moist by applying water to the top surfaces and allowing it to run down the concrete. Perforated canvas hose is particularly suited to such work, as stains which may occur when iron pipes are used, are avoided. This method which may be applied as soon as the forms are removed, has the disadvantage that it is apt to leave a streaked and unsightly surface.

9. Curing compounds (Membrane curing)

Under certain conditions it is desirable and advantageous to cure concrete by applying to the exposed surfaces a liquid curing compound designed to seal the surface and thus restrict evaporation of water. A properly applied, effective sealing compound will, under most conditions, retain enough water in the concrete for adequate curing, particularly if its application is preceded by wet curing, and this method is generally accepted as satisfactory.

Bituminous water emulsions and coal tar cutbacks produce films which retard evaporation appreciably, but because of the undesirable appearance, the use of these black coatings is generally restricted to surfaces which are later to be backfilled or otherwise kept from public inspection. Furthermore, in sunny weather these black coatings permit the absorption of so much heat that the result may be loss of moisture and increased tendency towards cracking and crazing. Whitewashing the black surfaces reduces heat absorption, but these white coatings disintegrate rather rapidly and require constant inspection and repair.

Clear curing compounds, generally on a wax-resin base, are often used where water curing is impracticable and black coatings are undesirable. When applied to con-

crete surfaces exaporation of the solvent leaves a membrane which is sufficiently elastic to take up the expansion and contraction of setting concrete without rupturing, and which greatly retards evaporation of moisture from the concrete. Acceptable compounds produce films which remain intact from 2 to 4 weeks, after which they usually disintegrate and can easily be removed by brushing. Most compounds contain a fugitive dye as an aid in ensuring complete coverage, and this dye fades out during the curing period. Compounds are generally applied imediately after free water has disappeared from the concrete surface which has just become dull, but it is sometimes necessary to augment membrane curing with initial water curing in order to keep the cement paste saturated and to counteract the effect of self-desiccation. This is, for example, the case when the concrete surfaces have been permitted to dry out, when forms have been in place for more than 24 hours and for all concrete with w/c ratios lower than 0.4. In all such cases the concrete should be soaked for about 24 hours before the sealing compound is applied.

Compounds are best applied by spraying, and spraying equipment should be of the pressure tank type with provision for agitation of the contents during application. Brush application may be used on formed surfaces, but not on unformed concrete, because the early application will mar the surface and the continuity of the membrane will be broken.

Surfaces treated with clear compounds should be shaded for the first 3 days to prevent evaporation and heating. As shading may be difficult to accomplish, white-pigmented compounds are recommended for all surfaces exposed to direct sunlight, as these have an effect equivalent to clear compounds with shading and thus reduce cracking and crazing.

The coverage necessary to ensure effective curing varies with weather conditions and surface textures, and 2 coatings are sometimes necessary in order to eliminate pin holes, which reduce the effectiveness of the seal.

Clear curing compounds, as well as those containing dyes or pigments, may blemish concrete surfaces unless they can be completely removed by brushing or washing, and this must be taken into consideration if they are to be used on surfaces exposed to public inspection. Where surfaces to which a compound has been applied are to be rendered, plastered, painted or bonded with other concrete, the membrane should be such that it will not interfere with the bond desired.

10. Air curing after moist curing

A period of air curing after adequate moist curing increases the resistance of the concrete to weathering, leaching and sulphate attack, because the surface is densified by the action of the carbon dioxide in the air. Piles, prefabricated units of hydraulic structures and similar concrete members should therefore—after adequate moist curing—be air cured for approximately 14 days before being submerged.

Cold weather curing precautions

Strength development in concrete which is not frozen immediately after placing is not only a function of age but also of temperature, as illustrated in Fig. 2. All other conditions being equal, the strength of such concrete will depend on the maturity, which is expresed as the product of the age of the concrete and its average curing temperature. The latter is reckoned from—10° C, as this is the temperature at which strength development is completely arrested. Thus, if a given concrete attains sufficient strength for the forms to be stripped after, say, 3 days' curing at 20° C, the same concrete will require 4½ days' curing at 10° C in order to attain the same strength [(20+10)×3=(10+10)×4½]. It is necessary, therefore, that concrete placed in cold weather be cured for longer periods or at higher temperatures than normally, in order to obtain sufficient strength development.

Temperatures below freezing are definitely harmful to fresh concrete because of the expansion which takes place when water is transformed into ice. This expansion causes a separation of the solid particles in the concrete, permanently reducing their bond, and average concrete which is frozen immediately after placing and then cured at normal temperatures, shows a loss in strength of approximately 50% in relation to comparable unfrozen concrete. On the other hand, if concrete is protected against freezing for the first few days, it may be frozen solid without injury and subsequent curing will lead to normal gain in maturity. Concrete placed in sub-freezing weather must, therefore, be protected against freezing until it has attained sufficient strength to withstand the forces created by the transformation of free water into ice.

Detailed procedures for curing concrete in cold and sub-freezing weather are beyond the scope of this article and for such details the reader is referred to special literature on the subject (e.g. "Recommended Practice for Winter Concreting Methods" A.C.I. Committee 604; and S.B.I. Anvisning No. 17 Betonstobning om Vinteren, revised edition). The following general comments may be made:

For concreting in near- or sub-freezing weather, it is generally accepted that concretes should contain entrained air and about 1% $CaCl_2$ by weight of cement. *(In some countries the use of $CaCl_2$ in reinforced concrete is prohibited, although there is no evidence indicating that small amounts have any corrosive effect on embedded reinforcement. Drying shrinkage may, however, be increased, sometimes as much as 50%.)* For such concretes the following is good practice:

1. Daily mean temperature 5° C or higher: 48 hours' protection against freezing is sufficient.
2. Daily mean temperature below 5° C: concrete should have a temperature of not less than 10° C as placed, and this temperature should be maintained for at least 72 hours, and be followed up by 3 days' protection against freezing.

The protection required in cold weather to keep the temperature of the concrete from falling below the specified values for the specified initial periods, is generally attained either by insulating or heating the placed concrete, or by heating one or more of the ingredients of the mix.

Insulation is effected by covering the fresh concrete with a sufficiently thick layer of straw, shavings, insulating board, by using insulated forms or by providing a dead-air space adjacent to the concrete, and the object is to prevent dissipation of the heat developed in the concrete by the hydration processes or from heated ingredients.

Heating may be effected by enclosing the structure (for example with tarpaulins) and surrounding it with an atmosphere warm enough to maintain the required temperature. Such enclosures should be tight and windproof, and should provide sufficient space for circulation of warm air. Heat may be supplied to the enclosure by live or piped steam or by stoves of various types, but all methods other than live steam have the disadvantage of drying out the concrete unless all exposed surfaces are kept continuously moist by spraying. Ambient air temperatures of 35°-40° C are generally sufficient to maintain initial concrete temperatures of 10° C, and losses in ultimate strength are then negligible. Both faces of concrete sections should be exposed simultaneously to the warm atmosphere in order to avoid stress-producing temperature gradients, and the concrete should be allowed to cool down gradually within the enclosure, as sudden drops in temperature are liable to result in surface cracking.

When it is necessary to heat the ingredients of a mix in order to produce suitable fresh concrete temperatures, it is common practice to heat the mixing water and sometimes also the aggregate. Water has the advantage that it can be heated more easily and has about 5 times as many heat units per unit weight as aggregate or cement. The temperature of heated mixing water should never exceed 70° C, as higher temperatures may cause flash set of the cement.

No matter what method is used to protect concrete during cold weather concreting, it should be remembered that considerable evaporation can take place in sub-freezing weather, especially if there is any wind, that corners and edges of members are most vulnerable and require special attention, and that concrete must be cooled gradually at the end of the curing period as surface cracking may otherwise result.

Hot weather curing precautions

Particular attention to curing requirements is necessary in hot, dry weather because of the increased danger of crazing and cracking occurring due to rapid evaporation of moisture from the concrete surfaces. Need for adequate continuous curing is greatest during the first few hours after placement.

Fresh concrete should not only be kept continuously moist, but should be shaded from direct sunlight and sheltered from winds. Wet burlap, preferably in double layers, is recommended in this connection, as it also has a definite, but not excessive, cooling value.

Intermittent spraying which allows the surface of the concrete to dry out between periods of sprinkling should be avoided, as contraction and expansion of the surface layer due to varying moisture content increase the risk of crazing and cracking. Curing water should not be much cooler than the concrete because of temperature-change stresses which would be introduced, with resultant cracking.

Sealing compounds retain less water in the concrete in hot, dry weather, and initial moist curing becomes vitally important, as does also the use of white-pigmented compounds. Dark coloured compounds should be avoided or should be whitewashed promptly to reduce heat absorption.

Steam curing

Curing concrete with live steam at atmospheric pressure is not only used for cold weather concreting but also under normal conditions, when high early strengths are obtained by combining higher curing temperatures with favourable moist conditions.

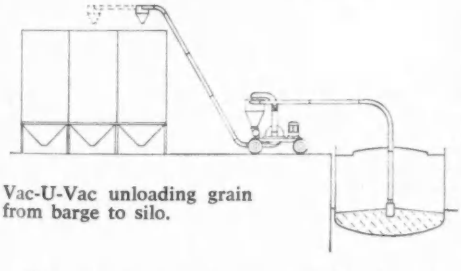
It has been mentioned that high curing temperatures lead to modifications of the hydration products which may, in turn, lead to losses in ultimate strength. The rate of strength development and the ultimate strengths obtained will depend on several factors, such as the curing temperature and the rate at which concrete is heated, and it has been found that optimum results are obtained if the concrete is heated slowly, maintained at between 55° and 75° C and then cooled down slowly. Higher curing temperatures will produce greater strengths at very early ages, but the ultimate strength losses may then be serious.

Steam curing at high pressures is also used but is only of interest for prefabricated products. This method has the advantage that very high early strengths are obtained and that shrinkage is greatly reduced.

Manufacturers' Announcements

Vac-U-Vator Grain Handling Unit

The Vac-U-Vator machine is designed for the pneumatic handling of most types of grain and certain other materials which are free-flowing and have a low moisture and dust content. It is a completely self-contained and portable unit, mounted on chassis and wheels and, apart from its obvious application for the transfer of grains to and from silos, rail and road transport etc., it can be adapted for loading and unloading grain vessels. In fact, it is this latter usage which has so far proved to be the major interest in Great Britain.



Vac-U-Vac unloading grain from barge to silo.

The standard unit can be fitted with diesel engine, petrol engine or electric motor. The diesel engine produces the greater flexibility in operation and is rated at 62 b.h.p. at 2,000 r.p.h. on a 12-hour rating, at which speed, fuel consumption under normal running conditions is between 2½ and 3½ gallons per hour. The electric motor is employed only where the danger of fire is prevalent and in this case, somewhat larger pulleys and belts are required to cope with the higher torque starting loads.

As with all handling units operating on pneumatic principles, it is difficult to give exact conveying capacity figures per hour. However, where the conveying and elevating distances involved are reasonable and practical, the machine should handle most types of grain at average capacities of between 20 and 25 tons per hour. Where necessary, the standard portable unit can be dismounted and installed as a stationary installation.

The Vac-U-Vator has a large potential market in the grain growing areas abroad and, in view of this, careful consideration has been given to the problem of providing adequate service and maintenance facilities overseas. An interesting application of the machine is already operating in the United States where a number of Vac-U-Vators are used first to load the grain vessel at the port of departure and then, placed on deck at the destination port, to unload into containers on shore.

The sole manufacturing and sales rights throughout the world are owned by Aldersley Vacuvators of Wolverhampton.

Arc Control Circuit Breaker

Johnson and Phillips, Ltd., London. S.E.7 announce the production of a new Type PDB arc-control circuit breaker. This breaker has achieved very high standards of performance during exhaustive tests exceeding the requirements of British Standard 116 at the K.E.M.A. Laboratories. It incorporates a number of new and unusual features and offers a margin of safety greatly in excess of that previously available.

Compressors for Cumbrae Lighthouse

As announced in these columns of the October 1959 issue, new equipment for the Cumbrae Lighthouse was recently supplied to the order of the Clyde Lighthouses Trust by Stone-Chance Ltd.

Each of the duplicate power plants, one of which operates automatically in the event of mains failure, consists of a Rolls-Royce diesel engine directly coupled to a McFarlane alternator and a Broom and Wade compressor. These two compressors must be completely reliable and efficient as they are used to provide compressed air for the diaphone fog signal which alone indicates the position of the light to shipping when the beam is ineffectual in fog or murky weather.

The two Broomwade Compressors installed in Cumbrae Lighthouse

Delivering 320 c.f.m. at 100 p.s.i., the compressors are engine-driven irrespective of whether the mains supply fails or not. The engine compressor sets also have alternators associated with them so that if the engines are running to provide emer-

gency electric current during a mains supply failure and at the same time compressed air is required for the fog signal, then the compressors are clutched in. If, on the other hand, the mains supply is sufficient and compressed air is required for the fog signal, then the engine-driven compressors are run, but the alternators are not connected to the lead.

The compressors were supplied by Broom and Wade Ltd., High Wycombe.

New Three-Purpose Tractor

A new industrial tractor-mounted digger and power shovel unit has been announced by Massey-Ferguson of Coventry and Manchester. The tractor, which will be known as the Massey-Ferguson 702, embodies many years experience in the industrial field and provides the power for this three-in-one unit which will prove invaluable to builders, civil engineering contractors, public works authorities and transport undertakings.

The digger can be dismounted in five minutes; the power shovel can be removed as quickly, leaving the tractor as a heavy duty mobile power unit.

When used with the front mounted power shovel, the 710 rear-mounted digger forms a composite team capable of tackling a wide variety of tasks. It has been successfully used to dig trenches, drainage channels and for dredging and clearing irrigation canals and ditches. Hydraulically operated pads take the strain off the rear end of the tractor when the digger is at work and the front shovel bucket is inverted and lowered to the ground to provide additional anchorage. This combination of the rear pads and front bucket

The equipment working on river bank

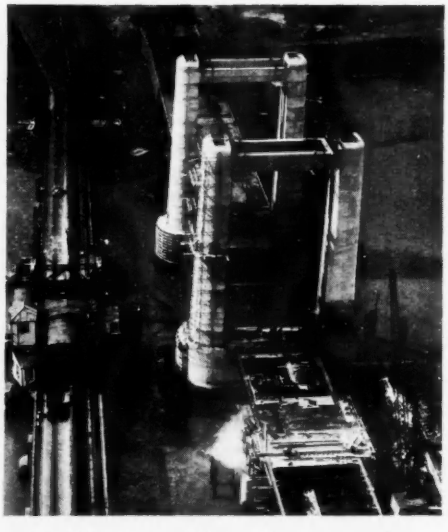
enables the equipment to be safely used on river and canal banks for both dredging and bank maintenance works.

When centrally mounted the digger has a 185 degree operating arc and is capable of digging at right angles to the tractor centre line, enabling it to work in confined spaces. It has a reach of 13-ft. 8-in. (17-ft. 5-in. from centre of tractor rear axle) and can dig down to a depth of 12-ft. An important feature, which adds greatly to its usefulness, is the fitting of the unit to either side of the rear frame as an alternative to the centre. The change-over is a short job enabling trenches to be dug close to walls and fences. This feature is the subject of a patent application.

The front mounted 702 power shovel combines high output with versatility. Alternative buckets for different applications are available together with a range of special attachments, including a fork lift angle dozer, crane and scarifier.

Kingsferry Bridge, Kent

Work is well advanced on the construction of the new Kingsferry Lifting Bridge over the River Swale, joining the Isle of Sheppey to the Kent mainland. The bridge will be opened to traffic this autumn, five months ahead of the contract time which allowed for completion in March, 1960.



The Kingsferry Bridge under construction

The design of the bridge is of the vertical lifting span type and provides a clear 95-ft. wide fairway for shipping. The lifting span is raised on four reinforced concrete piers about 130-ft. high, which give clearance for shipping of 95-ft. between high water and the raised bridge roadway.

The 650-ft. long bridge is carried on two main piers flanked by approach piers on each side with shore abutments. It will have an overall width of more than 50-ft., which will include a railway track, a 24-ft. wide roadway and a 6-ft. pathway.

The foundations of the main piers go some 60-ft. below high water level and those of the approach piers some 80-ft. below high water level.

The lifting span, which will rise vertically between the towers, will weigh 425-tons (or 825 tons including the counterweights) and will be raised by electric motors, rising to its full height in 1½ minutes. The new bridge will replace the existing road-rail bridge which the Contractors will demolish after the new bridge has been opened to traffic.

The main contractors for the Bridge are Messrs. John Howard & Company Ltd., and the sub-contractors for the steelwork are Messrs. Dorman Long (Bridge and Engineering) Ltd. The contract price is in the region of £1 million. A total of 1,500 tons of steel and 16,000 cu. yards of concrete have been used in the construction of the bridge.

The Consulting Engineers are Messrs. Mott, Hay and Anderson, and the Employing Authority is the Kent County Council.

Nylon Webbing Cargo Net

Made from slotted nylon webbing, a completely new type of cargo net which offers substantial long-term economies, is now under trial. The great strength of the nylon together with the particular construction of the webbing make the net much stronger than the normal type of rope net currently in use. At the same time the nylon net is compact and light in weight. A 14-ft. square net, for example, weighs only 25-lb. but has made lifts of two tons with safety. Ease of handling is regarded as a major attraction, and it remains completely flexible under all conditions. When wet it does not stiffen or harden or greatly increase in weight and, since the nylon webbing is flat, trucks can run over it without difficulty.

The new nylon cargo net

Nylon nets also reduce labour considerably and the easier handling together with the ability to lift greater loads at one time will enable ships to be unloaded more rapidly with a consequent reduction in labour costs. The nylon net is durable and has double the life of a conventional rope net. It is rot proof, not harmed by sea water and has high resistance to abrasion.